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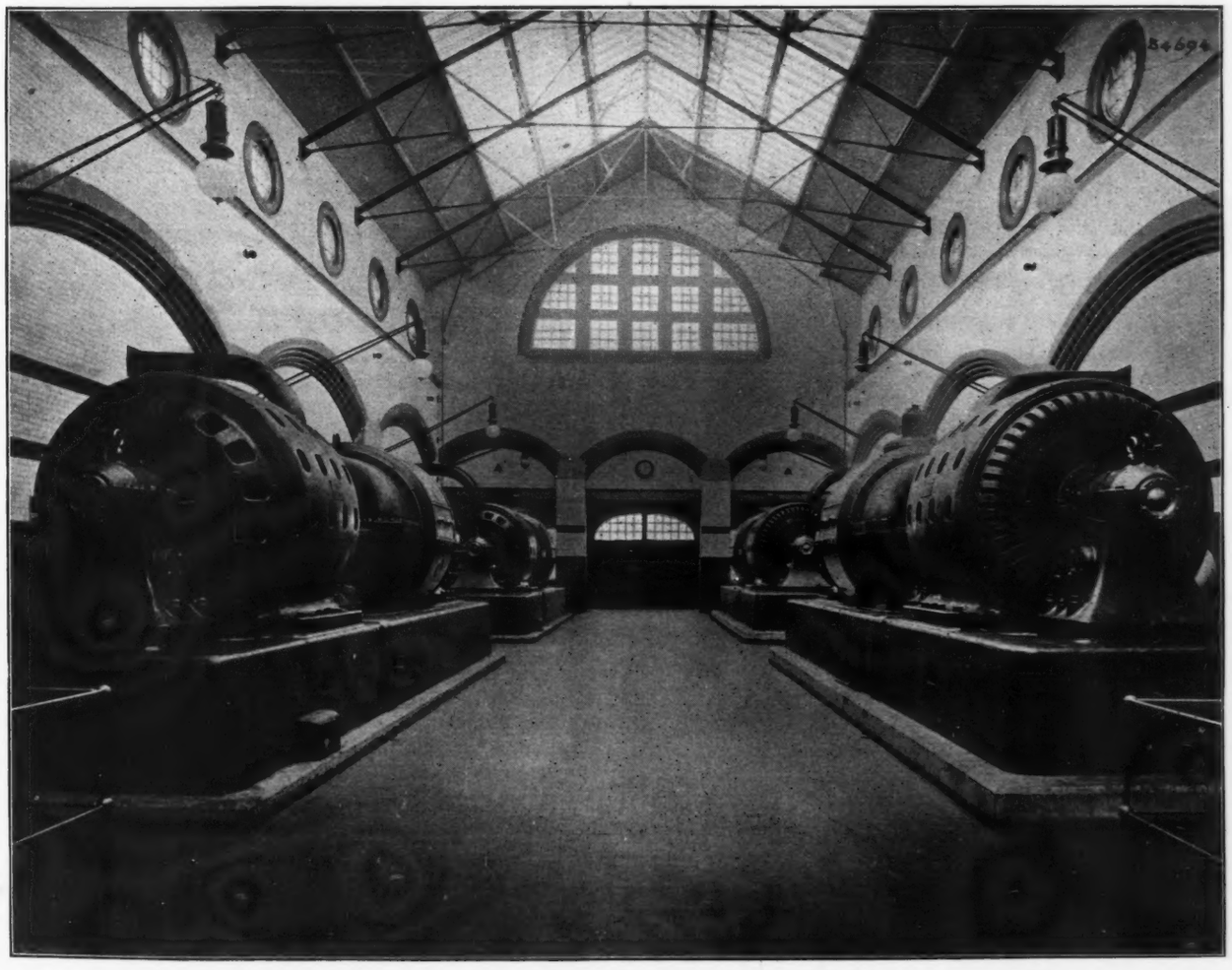
The Modern Steam Turbine in Central Stations and Power Plants.

As a supplement to the series of articles which have been recently published in the Journal on "The History and Development of the Steam Turbine," by Harry Y. Hayden, a description of a number of different types of turbines which have been installed in continental Europe, England and the United States, it is thought will be of particular value.

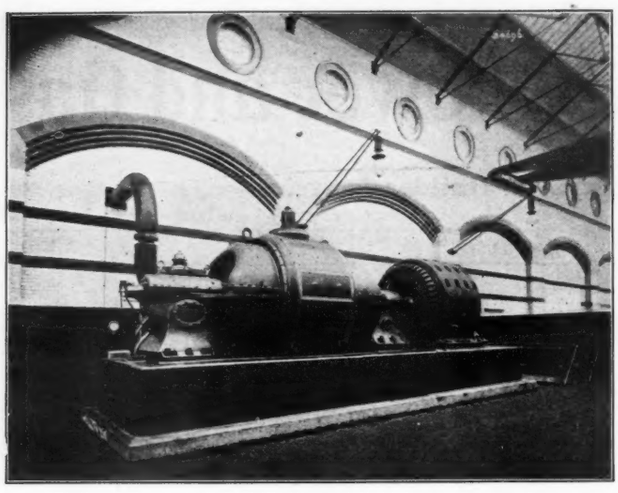
The installations described, while typical, are not considered to completely represent the general practice in turbine manufacture and operation at the present time. Nevertheless, the general principles involved are perhaps quite well covered in the different plants considered.

Among the most important central stations and power plants in Great Britain now utilizing steam turbines, the Chelsea Central Station in London, the Clyde Valley Power Plant at Glasgow, and the Lister Drive Station, owned and operated by the cty of Liverpool, as a municipal plant, are the most complete.

The interior of the Liverpool Central Station, containing two 2,000 kilowatt and two 1,600 kilowatt Westinghouse turbo-alternators, is shown in the accompanying illustration. These alternators supply current at 6,000 volts, and feed into the general system of service supplied from the various stations owned and operated by the city of Liverpool. Steam is supplied at this plant from Babcock and Wilcox boilers, equipped with superheaters and chain grate stokers. Green's Economizers are also used, and the condensing plant is of



10,000-Horsepower Municipal Steam Turbine Station at Lister Drive, Liverpool, showing Two 2000-Kilowatt and Two 1600-Kilowatt Westinghouse Turbo-Alternators.



One of the 1600-Kilowatt Westinghouse Turbo-Alternators at Lister Drive Power Station, Liverpool.

the Wheeler manufacture, installed by the Wheeler Condensing and Engineering Company.

The aggregate capacity of the Liverpool municipal station in electrical generators is 27,670 kilowatts. Of this amount, the maximum load for lighting and power is 9,475 kilowatts, while the maximum load for street railway service is 6,280 kilowatts. In the lighting system there are a total of 330,000 16 c. p. incandescent lamps, or their equivalent

During the past year the total number of kilowatt hours sold from these plants was somewhat over 31,000,000 Of this amount, 20,000,000 kilowatt hours were supplied for electric railway service. This electrical energy was sold for 1.07d, or about 2c per kilowatt hour. Electrical energy for public lighting was charged for at the rate of 2d, or 4c per kilowatt hour. For private purposes, 11,000,000 kilowatt hours were used, at a rate of 1d, or 2c per kilowatt hour, for power where the consumption was more than 3,000 kilowatt hours per quarter. For electric lighting the rate was 3d, or 6c per kilowatt hour, when the consumption was in excess of 3,000 kilowatt hours per quarter.

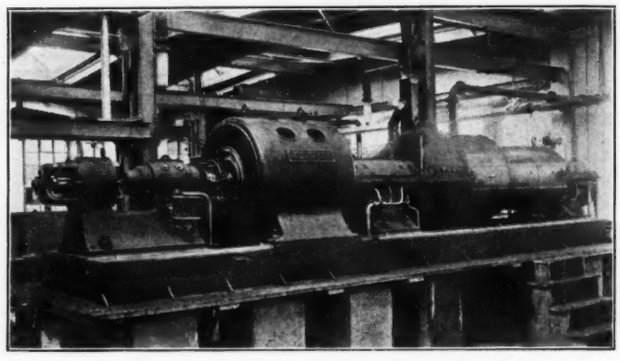
In connection with this plant, it is interesting to note that waste refuse is burned for generating electrical energy for lighting in five garbage incinerating plants, and the sanitary department of the city has contracted with the electric light and power corporation to furnish steam during the coming year to the extent of 7,000,000 kilowatt hours. At the Lavrock Bank incinerating plant there are eight cells and four water tube boilers, each having a heating surface of 1,265 square feet. About 110 tons of refuse is burned at this plant per day of eighteen hours, and the steam generated is delivered to engines having a normal capacity of 800 horsepower, the pressure of the steam being 160 pounds per square inch.

The city of Preston also utilizes its waste refuse for supplying steam for the generating of electric power which is used in operating its entire municipal railway system.

Among the largest steam turbo-generators ever constructed in America or Europe are the two units now in operation at Milan, Italy, and at Frankfort-on-the-Main, Germany. These turbines develop 5,000 horsepower, and the alternators have a maximum capacity of 3,600 kilowatts. Two types of steam turbines now being somewhat extensively introduced in Europe are those constructed on the Rateau system as used by Sautter, Harle and Cie, of Paris, and Brown, Boveri & Co., of Baden, Switzerland, and those manufactured by Messrs. Parsons, of England.

The steam turbine development in Germany, France and America has been quite rapid during the past three years, and if these installations prove a success for continuous operation there should be a great future for them.

The Curtis turbine, manufactured by the General Electric Company, has been installed in a number of power plants in America. A unit of this type is illustrated in the accompanying diagram, the particular drawing referring to this turbine having a capacity of 5,000 kilowatts, directly connected to an alternating current generator delivering

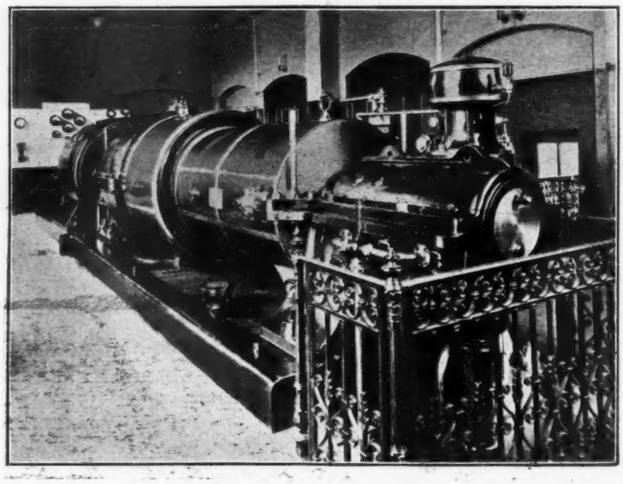


1350-Horsepower Steam Turbine and Alternator for the Troyes Plant under test in Baden shops.

three-phase current at 9,000 volts. The alternator has 6 poles, and runs at a speed of 500 r. p. m., thereby giving 3,000 alternations per minute, or a frequency of 25 cycles per second. It is given out by the manufacturers that the steam consumption of one of their 5,000 kilowatt two-stage vertical turbo-alternators is 19.75 pounds per kilowatt hour. Where it is desired to build these units of higher frequency it is accomplished by increasing the number of poles rather than the speed, an alternator of 60 cycles, for instance, having a speed of 514 r. p. m. These alternators, as manufactured by the General Electric Co., are also constructed in sizes of 500, 1,500, 2,000 and 3,000 kilowatts, the speeds varying from 1,800 to 600 r. p. m., and the frequencies being 25, 40, 50 or 60 cycles per second.

In continental Europe considerable investigation has been made in connection with the rotary steam engine, as well as the steam turbine, and the progress in this line of work has been perhaps as great as in England and America. Some of the developments in France and Germany of this class of prime mover are of considerable importance.

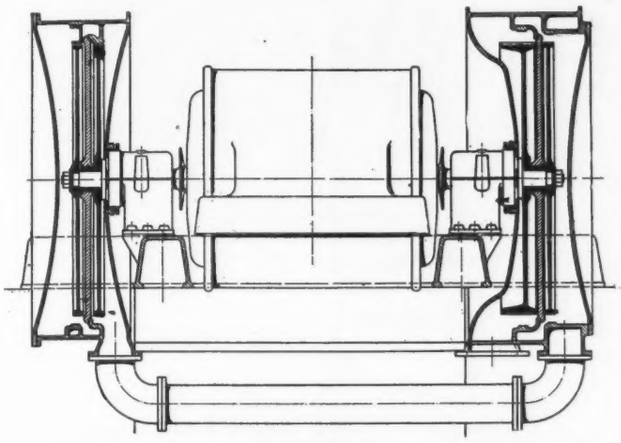
The accompanying cuts give an excellent idea of a three-phase alternator installed at the power plant of the Societe de Filatures de Schappe in Troyes. The view of the machine when completed and under test at the factory in Baden, Switzerland, shown in connection with the cut illustrating the unit installed, gives an excellent idea of the construction



1350-Horsepower, Three-phase Turbo-Alternator at the Power House of the Societe de Filatures de Schappe in Troyes.

as viewed from both the alternator and turbine ends. This turbine operates at a speed of 1,500 r. p. m., and is directly coupled to a three-phase alternator of 1,000 kilowatts capacity, supplying current at 510 volts and at a frequency of 50 cycles per second.

The compound rotary steam engine and electric generator as designed by A. Patschke is illustrated in the accompanying drawing. Units of this construction are built to operate from 500 to 750 r. p. m. The machine from which this drawing was made has a capacity of 36 horsepower, and was constructed at Mulheim a. d. Ruhr by H. Wilhelmi, who



Riedler-Stumpf Turbo-Alternator with Two Turbine Wheels.

states that this firm is in a position to construct this type of rotary engine up to 6,000 horsepower capacity, the mechanical efficiency of the machine to be from 80 to 95 per cent.

At Karlsruhe, Baden, the Elektra-Dampf-Turbine is being constructed for pumping purposes and also for the operation of electrical generators built by the Gesellschaft fur Elektrische Industrie. These machines are built having an output of from 10 to 100 horsepower, the details of construction being shown in the drawing. The 10 horsepower size operates at a speed of 4,000 r. p. m., the 50 horsepower at 3,000 r. p. m., and the 100 horsepower at a speed of 2,500 r. p. m. The wheels of the 10 horsepower unit are 250 mm. in diameter, and contain 200 vanes, the peripheral speed being 52 meters per second. The steam consumption is said to be 22 kgs. per brake horsepower for this size of unit. For the 50 horsepower turbine the steam consumption is given as 12 kgs per brake horsepower. The 50 horsepower unit has a wheel 522 mm. in diameter, containing 329 vanes, the peripheral speed being 82 meters per second. Another steam turbine which has been developed in Germany, and which has been somewhat extensively developed, is constructed in both vertical and horizontal types, and is known as the Riedler-Stumpf steam turbine, and is constructed by the Allgemeine Elektrizitats Gesellschaft of Berlin.

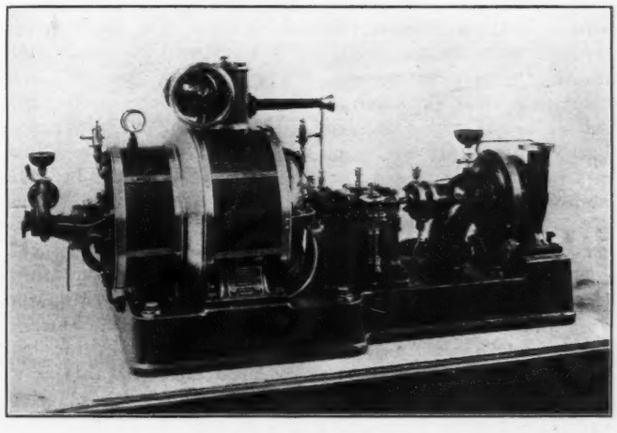
The principle involved in the design and construction of these turbines is to reduce as far as possible the number of revolutions consistent with the economical utilization of the steam. They are built on the principle of the Delaval turbine, with the wheels very much larger in diameter. By this modification the necessary high peripheral velocity is obtained without the very high speed in r. p. m. otherwise required. The revolving wheels are built of nickel steel discs with a high factor of safety, great care being taken to perfectly balance these wheels so that the center of gravity is exactly in the center of rotation. The blades or vanes are milled in the rim of the steel wheel, the bearings being located as close as possible to the disc. These blades are built in pairs quite similar to the buckets of an impulse water wheel.

The 2,000 horsepower Riedler-Stempf horizontal turbine illustrated in the drawing is constructed with the electrical generators placed between the two wheels. A machine of this size and type is in operation at the Moabit Electric Supply Station, the steam pressure being 200 pounds per square inch absolute, at the temperature of 294 degrees C., and a vacuum of 85 per cent in the condenser. The dynamo is directly coupled to the wheel of the turbine, the weight of which is 850 kg. The workmanship is so good that it is stated the mechanical efficiency is very close to 100 per cent.

In some types of the Riedler-Stumpf turbine the kinetic energy of the steam is utilized in a number of wheels in succession instead of in one row of blades. A part of the energy only is used for the first wheel, the angles of the vanes being so designed that the point of outlet and inlet guide the steam to a second moving wheel, where a part of its energy is given up, and then on again to a third wheel in the same manner. There is, of course, a limit to the number of velocity stages which can be utilized with economy, since friction of the steam would be large if an excessive number were employed.

This type of turbine is in some cases designed with centrifugal jet condensers attached to the turbine shaft, so that the steam enters through an annular channel from the last moving wheel to the condenser wheel, mixing with the cold water coming in through the pipe provided for the purpose, while the mixture flows away through another pipe. It is said that this type of centrifugal jet condenser is applicable to the horizontal type of turbine as well as to the vertical type.

A test of these turbines at the Berlin Electric Supply Station showed a steam consumption of 20.3 pounds per kilowatt hour at half load, the steam pressure being 116 pounds per square inch, speed 3,000 r. p. m., and steam temperature of 290 degrees C. Half load corresponded to 850 kilowatts, and with a load of 1,365 kilowatts, steam pressure 130 pounds per square inch, steam temperature 294 degrees C, the speed remaining the same, the steam consumption is given as 19.6 pounds per kilowatt. With a load of 1,920 horsepower, steam pressure 170 pounds per square inch, steam tempera-

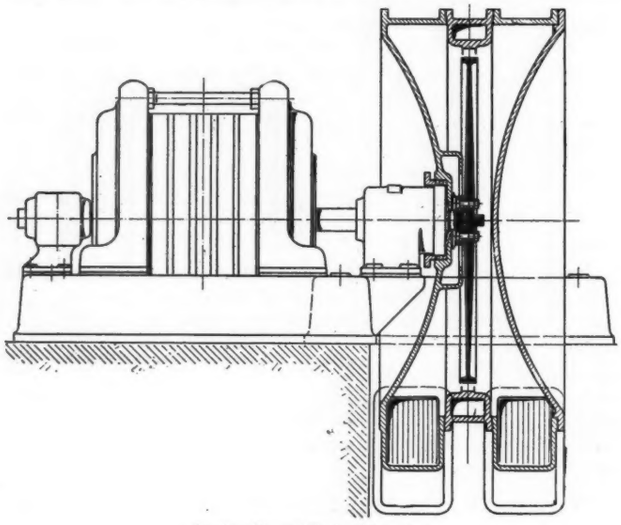


Rateau Steam Turbine.

ture 300 degrees C and speed of 3,800 r. p. m., the steam consumption is given as 17.4 pounds per kilowatt.

One of the most important types of steam turbine constructed on the continent of Europe at the present time is that of Professor A. Rateau of Paris, and manufactured by Sautter, Harle & Cie. The accompanying illustration and drawing show the details of construction of these turbines. One of the first units constructed by Professor Rateau was built with a single moving wheel, formed with vanes in the shape of a double arc, all milled out of a solid block of steel, the buckets being quite similar to that of the well-known impulse type of water wheel, and also in general of the same

form as the vanes of the Delaval and Riedler-Stumpf turbine. The latest type of Rateau steam turbine is one in which the expansion of the steam is carried out in the distributor for each group and moving wheel, the turbine being of the action type, the motion resulting from the velocity rather than the pressure of the steam. The Rateau turbine is said to be of the multicellular form, consisting of a number of elements, each of which includes one moving wheel and one distributor. The wheels revolve in a chamber where the pressure is uniform, and it is stated for this reason that there is no longitudinal thrust upon the moving parts, thereby removing the necessity for dash pots to overcome the effect of this thrust. In the Rateau turbine the moving wheels are constructed of discs of thick sheet steel, upon the periphery of which are riveted the cylindrical vanes. A steel band is riveted to the periphery to maintain the correct spacing of the vanes and to produce a rigid structure. The moving wheels turn between circular diaphragms which are provided with distributing vanes which enter into grooves

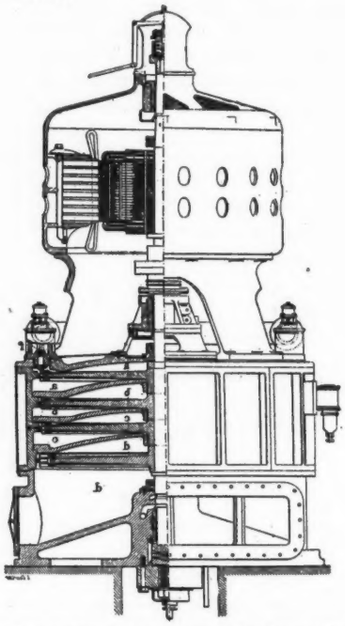


Riedler-Stumpf Turbo-Alternator.

formed in the interior of the turbine case. The shaft passes through the diaphragm in collars of anti-friction metal, thereby producing a very slight friction. In the first diaphragm through which the steam passes the distributing frames are placed only upon a part of the circumference. Partial injection of the steam is therefore obtained, resulting in a better utilization of the velocity of the steam. In addition to producing the same effect, the useful part of each distributor is set with an angular advance as compared with that of the preceding section. This angular advance is calculated according to the speed of rotation so that the steam leaving one wheel enters into the following distributor and does not encounter a solid wall, which would produce a shock and thereby a loss of kinetic energy. In the last wheels it is necessary to employ total injection, that is to say, the distributing vanes are set upon the whole circumference of the diaphragm; moreover, on account of the expansion of the steam, the radius is necessarily increased.

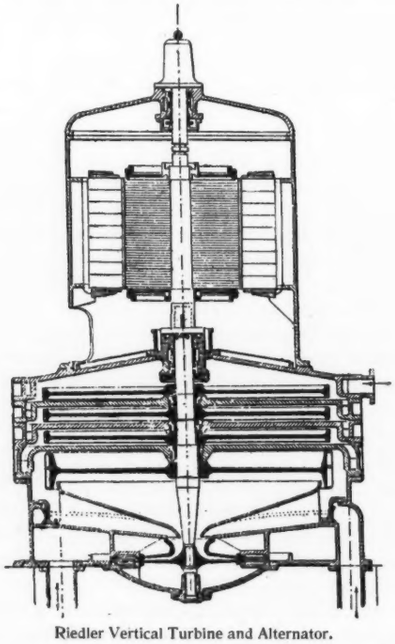
The bearings of these turbines are external, and by means of a special system of spring packing they are kept tight. No oil is carried by the exhaust steam to the condenser, this being an important advantage, inasmuch as the water of condensation can be used for feeding steam boilers without the necessity of an intermediate oil separator. The speed is controlled by a centrifugal governor equipped with a Denis compensator acting upon an obturator, which controls the pressure of the steam entering the turbine.

There is now being installed in the steam driven substation of the Los Angeles Electric Co. a 7,500 kilowatt Westinghouse-Parsons steam turbine, the illustration of which shows its general construction. In this station there are also two 2,000 kilowatt Curtis turbines, which have been in operation for some time. The enclosed type of alternator, driven by a Westinghouse-Parsons steam turbine, is also shown. A number of turbines, both Westinghouse-Parsons and General Electric, of the Curtis type, are being installed on the Pacific Coast.



Curtiss Vertical Turbine and Alternator of The General Electric Co.

In a paper by Professor Rateau entitled "The Different Applications of Steam Turbines," he gives some interesting data in reference to direct current turbo-dynamos, which are illustrated in this article. These machines were installed in the central electric lighting station in the mines of Penarroya, Spain, a little more than a year ago. Three groups of these

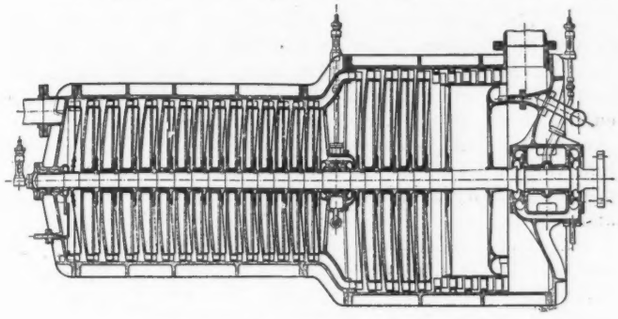


Riedler Vertical Turbine and Alternator.

machines, each developing 500 horsepower at 240 volts, direct current, comprise the plant. Each turbine generating set includes two turbines for high and low pressures and two dynamos for direct current, the generators being directly driven by the two turbines upon the same shaft and upon the same bedplate, the two generators supplying a three-wire system having a potential of 480 volts between the outer

wires. These machines operate at a speed of 2,200 r. p. m., the total floor space occupied by each unit being 12 feet in length, 5 feet 6 inches in width and 5 inches high. The condensation of the steam is carried out by means of ejector condensers of a special type designed by Professor Rateau.

Tests were made of the first group in September, 1902.

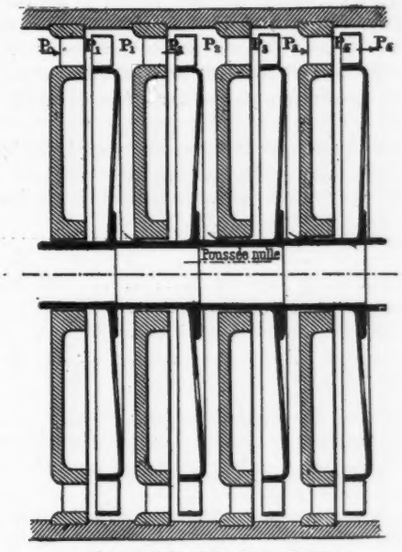


500 Horsepower Rateau Turbine at Penarroya.

Great care was taken to obtain accurate results in this test. The detailed results are set forth in the following table. In the tests the condensation was accomplished by means of a surface condenser installed at the works so that the water of condensation mght be collected and measured. It is to be noted that the vacuum in the condenser reduced as the power increased. This is due to the fact that the condenser was designed for machines of about half the capacity, and was therefore of too small a size for the larger volume of the steam.

	¼ Load	½ Load	Full Load	Over Load	Over Load at 2400 rev
Electrical horsepower at brushes	135	259	525	627	641
Admission pressure absolute pounds per square inch.....	46.21	76.6	136	156	156
Exhaust pressure absolute pounds per square inch.....	1.24	1.33	1.63	1.82	1.82
Theoretical steam consumption of perfect engine per horsepower hour. Pounds	10.93	9.8	8.98	8.73	8.75
Actual steam consumption per electrical horse power hour at brushes. Pounds	21.3	18	15.8	15.39	14.9
Combined efficiency of the electrical generating set.....	.513	.540	.560	.569	.580

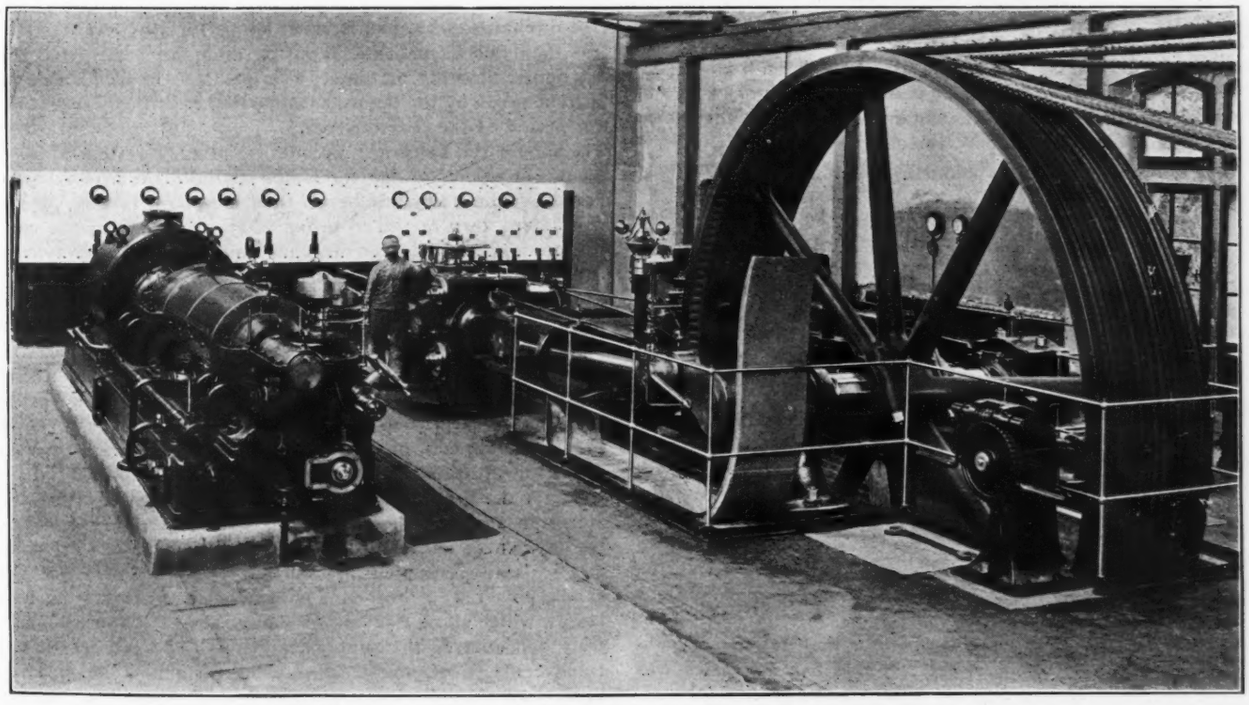
From the data given above it is seen that a turbine developing 644 electrical horsepower and working without appreciable superheat between an admission pressure of 156 pounds absolute and an exhaust pressure of 1.8 pounds consumed 14.9 pounds per electrical horsepower at the terminals. Also the combined efficiency for the set is 59 per cent when compared with the energy contained in the steam for the same fall of pressure. With the steam at 180 pounds, superheated 50 degrees C, and a 29-inch vacuum at 2,400



Rateau Multicellular Steam Turbine.

r. p. m., the steam consumption is decreased to 11.5 pounds per electrical horsepower.

These units were for the generation of direct current. For driving alternators there is naturally much less difficulty in the design of the generators than when using direct current machines. The entire absence of the commutator in alternating current generators makes it possible to run the machines at much higher speed. Many types of alternators



1200-Horsepower Steam Turbine and Reciprocating Engine at Colmar Power Plant of Messrs. Kiener & Co., Showing the Comparative Space Occupied by These Two Types of Prime Movers.

have therefore been successfully driven by turbines. The rotating element of each alternator, however, must be mechanically of the best possible construction. The rotating field type is naturally the best form of alternating current generator for direct driving of the steam turbine.

Fifteen hundred revolutions per minute is practically the limit for a frequency of 50 to 60 cycles per second. Probably the magnetic leadage is somewhat greater in the turbo type of alternator than in machines of lower speed, and it is somewhat more difficult to build up the rotating part of the alternator so that it is perfectly balanced. These conditions are, however, being rapidly overcome with alternators driven by steam turbines. The much greater mechanical efficiency, however, along other lines, is of decided advantage.

A turbo-alternator of the Rateau type, built by Messrs. Sautter, Harle & Cie, in the generating station of the Loirs Electricity Co., was tested with the following results:

Speed, revolutions per minute.....3,000
Steam pressure .....170 pounds absolute
Back pressure of exhaust.....2.85 pounds
Electrical output at terminals.....388 horsepower
Steam consumption per electrical horsepower, including excitation .....19.2 pounds
Combined efficiency .....48.7 per cent

It is said that the efficiency could have been much improved by increasing to a slight extent the dimensions of the turbine, which had only twelve moving wheels; nevertheless, this efficiency compares favorable with other turbine sets having the same power. The guaranteed results of three sets working with superheated steam, to be installed in the factories of Pavin de Lafarge at Eeil (Ardeche), are as follows:

Steam pressure at turbine.....156 pounds
Vacuum in the condenser.....26 inches
Temperature of steam.....270 degrees C.
Consumption of steam per electrical horsepower at terminals, including excitation.....15 pounds
These machines are all fitted with ejector condensers.

From data of the above and other similar tests, the manufacturers of these turbines estimate that a machine of 2,000 kilowatts, running at 1,500 r. p. m., would have a turbine efficiency of 68 per cent. Based upon this figure, the following guarantee could be given, assuming the use of superheated steam and the condenser giving a satisfactory vacuum, which it is claimed is easy to obtain with a steam turbine in which there is no entrance for the air:

Pressure of steam on admission to turbine..200 lbs.
Vacuum in the condenser.....29 inches
Temperature of steam.....350 degrees
Consumption of steam per brake horsepower upon the shaft of the turbine.....8.5 lbs.

If this figure were obtainable it would be a far better result than is obtained by use of the reciprocating engine.

PERSONAL.

Mr. W. S. Heger, Vice-President and General Manager of the Allis-Chalmers Company of Milwaukee, has been a welcome visitor in San Francisco for the past week. It was with pleasure that the writer listened to his encouraging comments on the upbuilding of the city, while it was with great surprise he noted the rapid progress being made, that which seemed to impress him with the most importance was the volume of business being done under the adverse conditions that exist.

Mr. Heger offered the suggestion that too much publicity could not be given to the fact that San Francisco was alive and building her city as rapidly as labor could be secured to do it, as the people in the East were still very skeptical.

POWER PLANT ECONOMICS.

The following summary is presented in connection with a valuable paper on "Power Plant Economics' presented before the New York meeting of the American Institute of Electrical Engineers by Mr. Henry G. Stott.

1. The present type of steam-power plant can be improved in efficiency about 25 per cent by the use of more scientific methods in the boiler room, by the use of superheat, and by running the present types of reciprocating engines high pressure, and adding a steam turbine in the exhaust between the engine and the condenser. At the same time the output of the plant can be increased to double its present capacity at a comparatively small cost for turbines and boilers.

2. The steam-turbine plant has an inherent economy 20 per cent better than the best type of reciprocating engine plant, not so much due to its higher thermal efficiency as to a variety of causes.

3. An internal combustion engine plant in combination with a steam-turbine plant offers the most attractive proposition for efficiency and reliability to-day, with the possibility of producing the kilowatt-hour for less than one-half its present cost.—American Engineer and Railroad Journal.

AN INGENIOUS FRAUD.

An esteemed contemporary, the "Hardwareman," has recently exposed in its columns a peculiarly ingenious form of electric light fraud, which is being worked in various parts of the country, and from its nature is calculated to entrap the unwary electric light consumer, or even the wiring contractor if his electrical knowledge be little and therefore dangerous. As it may be the means of saving some of my readers, or, at all events, their clients, from being victimized, I give the modus operandi herewith. There is a London firm of so-called electrical engineers, who are approaching various electric light consumers throughout the country with an offer to reduce their quarterly accounts for electrical energy, and, what is more, to do it on the installment plan, "no saving, no payment." To this end they offer to supply the consumer, free of charge, with incandescent lamps for any period of not less than twelve months, taking payment for same from the consumer, monthly, in sums to be paid on the cash value of current saved by the lamps, as compared with the corresponding period of the previous year.

Should the consumer not desire an easy system of payment, but proffer to buy the lamps outright, the firm are prepared to submit any number of their lamps for testing, on the consumer's own meter, to prove what saving in current consumption is effected over the same number of lamps previously used. A condition of this test is that the consumer shall use new lamps in competition with the current-saving variety, in order to make the test apparently more fair. So far as current consumption goes, the offer is perfectly bona fide: the new lamps supplied by this enterprising firm do show a saving as compared with the ordinary 16 candle power incandescents so largely used for the electric lighting of shops, hotels, restaurants, private houses, etc., but the trick consists in the substitution of a foreign-made 8-c. p. lamp, marked 16-c. p., for the genuine 16-c. p. lamps already in use. With the aid of an ammeter these traveling salesmen readily convince the layman of an acknowledged electrical fact—viz. that an 8 c. p. lamp consumes less current than one of twice the candle-power, and the result is usually an order for the new lamps, which show a saving of about 33 per cent on the quarterly accounts of the supply company. The essence of the fraud consists, of course, in showing off a new 8-c. p. lamp against an old one of 16-c. p. The one takes less current, and is, apparently, more brilliant, hence the trapping of the unwary.—"Electricity."

THE INDIANAPOLIS, NEW CASTLE & TOLEDO ELECTRIC RAILWAY.

The State of Indiana, already netted with interesting systems of interurban railways, will soon have added to those now in successful operation a new line of electric railway between Indianapolis and New Castle, Ind., as the main terminals, with branch lines to Greenfield, Anderson, Muncie, Winchester and Richmond, the total mileage of which is as follows:

Indianapolis to New Castle	45 miles
Maxwell to Greenfield	5 "
Shirley to Anderson	16 "
New Castle to Muncie	20 "
New Castle to Winchester	28 "
New Castle to Richmond	26 "
Total	140 miles

The location of the new system is quite as favorable as that of a majority of the present well-paying properties of Indiana. This road will serve as the only means of railway communication with Indianapolis for a large percentage of the population reached by its service; in fact, no portion of the trackage is crossed by a competing railway. A private right-of-way, 50 feet wide, and terminal facilities controlled by the company in the City of Indianapolis, place the new system in a very favorable position for maintaining high speed through the country, and secure rapidity of entrance and exit from the city proper. In addition to the passenger traffic, the company's franchise permits the transportation of freight without any restriction.

A peculiar advantage possessed by the new road over the average project lies in the fact that the entire system tends to feed towards the City of Indianapolis, the State metropolis, which serves either as a point of consumption or distribution for most of the farming products, coal, and manufactured articles which originate on or adjacent to the lines of the new railway.

The engineering features of the road include the building and equipment of a main power station, located near New Castle, and ten permanent and one portable substations, one substation being installed in the main power plant building. The contemplated use of a portable substation is in keeping with well-established recent practice in general electric railway service. There are many interurban systems of which portions are liable at times to exceptionally severe loads, and the portable station is proving very useful in dealing with them. It can very readily be shifted from town as occasion requires, following up the shifting of spare cars and supplying additional power even at somewhat severe loss in the high-tension feeders.

The main power station will contain units of 1,000 kilowatts each, two Allis-Chalmers steam turbo-generating units being installed for present use to supply 25-cycle alternating current to the line by a system of step-up transformers operating at 33,000 volts. A line voltage of 33,000 volts was adopted, not only to meet the engineering requirements of the present system, but also because the voltage at the frequency selected would enable the system to mesh properly with practically all of the other similar systems now operating in Indiana, should future conditions so demand.

All transmission, both high tension and railway service, will be carried on pole lines, no third-rail construction being considered advisable.

Seventy-pound A. S. C. E. Section T rails, heavily ballasted, will permit of high speed train operation.

The schedule so far prepared contemplates hourly runs between Indianapolis and Richmond, with connections for branch roads laid out to provide the most thoroughly satisfactory service. Limited high-speed service will also be established between Indianapolis and Richmond, operating on three-hour headway and making proper connections with branch roads. An express service is allowed for, as well, and two 50-ton electric locomotives will be provided for freight haulage and switching purposes.

The contract for the entire construction of buildings and roadbed has been awarded to the Electrical Installation Company, of Chicago. Complete Allis-Chalmers power and electrical equipment will be installed in the main power station and three rotary converter substations, which will be built at once, the building of the remaining substations being delayed until later. The equipment for the main power station will, for the present, consist of two 1000-kilowatt turbo-generators to operate at 175 pounds steam pressure and 50 deg. F. superheat, the electrical ends of these units being wound for 25 cycles, 3-phase, 2300 volts.

The boiler equipment will be made up of three horizontal water tube boilers, 175 pounds gauge, with nominal rated capacity of 400-boiler horsepower each and fitted complete with mechanical stoking devices. Two boiler feed pumps are provided, each of sufficient capacity to handle the total amount of feed water necessary for operation of six 400-horsepower boilers at their normal rated capacity. The feed pumps are to be of the horizontal outside, center-packed plunger type. A feed water heater of the open cast-iron type will be provided, capable of handling 45,000 pounds of water per hour.

Two complete surface condenser equipments consist of the condenser proper, steam-driven air pump and centrifugal circulating pump, direct connected to a simple engine, each outfit capable of condensing 20,000 pounds of exhaust steam per hour. Two exciter generators will be furnished, one for each of the 1000-kilowatt turbo-alternators. Six 350-kilowatt, oil-filled, water-cooled, step-down transformers for a ratio of 2,300 to 33,000 volts will be provided. They are to be arranged in two banks of three each for connection to the alternators. Three converter transformers, each 150 kilowatts, oil-filled, self-cooled, step-down type, for 33,000 to 405 volts, will be provided for supplying current to the 400-kilowatt compound-wound rotary converter to be installed in the main power plant, 400 kilowatts, 25 cycles, 405 volts, A. C.-650 volts, D. C.

A 40-kilowatt, 120-volt, direct-current generator, provided for direct connection to a high-speed engine, will be so connected as to form a reserve for either one of the two direct connected exciters specified, so that in case of the breakdown of either one, the corresponding alternator will not be disabled. This generator will also furnish the station lighting.

The switchboard equipment for the main power station will be designed especially to meet the requirements of the service as laid out, with all the necessary protective apparatus and modern switchboard appliances.

The outside substations will each be provided with a 400-kilowatt, 25-cycle, 3-phase rotary converter and three 150-kilowatt, oil-filled, self-cooled transformers, similar to those already described.

Eight complete car equipments will be provided, each consisting of four 75-horsepower (75) railway motors, two controllers, Christensen air brakes, one set of rheostats and miscellaneous apparatus.

The motors specified for the car equipments are of liberal design, provided with large bearing surface, and particularly adapted to heavy interurban service.

The controllers which have been developed for use with these motors are made suitable for two and four-motor equipments. They are of the series parallel type and are provided with an efficient magnetic blow-out. The various combinations of motors and starting resistance are such as to give a smooth acceleration, and the controller operating handle may, if desired, be fitted with an automatic device which prevents the operator from notching the controller too fast and drawing an excessive current from the line.

The buildings provided for the system are, in general, designed with a view to rapid additions to the initial equipment when necessary.

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EDITORIAL.

THE DEVELOPMENT OF THE STEAM TURBINE.

The development of the steam turbine in recent years, particularly in connection with the generation of electrical energy in the shape of alternating current, has been quite extensive both in Europe and America. While not in every case as flexible as the reciprocating engine, there can be no question but that the steam turbine has many advantages over the older type of steam prime mover which has been in use in some form since the time of Watt.

The successful turbine plant, from an economical standpoint, has two definite requirements. First, it should be operated condensing with a good vacuum, and second, be supplied with superheated steam. In large installations both of these requirements may be readily provided. For small units the increased cost in installation and attendance to provide, under all conditions of operation, a vacuum of approximately 28 inches and 100 to 200 degrees of superheat, may be quite considerable, and in many cases so great as to seriously affect the final results as to the cost of power per unit of output.

Notwithstanding the very large amount of experimental work put upon the development of steam turbines, there are many types that can not be said to be mechanically as reliable in general operation as the old form of reciprocating steam engine. As is the case in many new and important pieces of apparatus, it has been necessary to develop suitable materials for the construction of the rotating parts of the steam turbine. The assembling of these parts into a rigid structure perfectly balanced requires the best workmanship, as well as a superior quality of material.

Alternating current generators for use with turbines are undoubtedly so constructed as to compare very favorably with the older type of alternator for direct connection to reciprocating engines. In some cases, however, difficulties in operation have arisen from faulty design in the alternator rather than from any inherent defect in the turbine itself.

For very large plants the steam turbine, supplied with superheated steam and provided with a good vacuum, is a most attractive substitute for the large and unwieldy reciprocating steam engine. The space occupied by the turbine is but a small fraction of that required for the steam engine. The disadvantage of the reciprocating motion of the engine is equaled somewhat by the excessive high speed of the turbine. Neither of these need give serious trouble, however, as long experience has abundantly demonstrated.

The really important considerations in large central stations may be summed up under two heads—economy, and reliability of operation. Except for the value of the space required, these two points are perhaps the only ones of paramount importance. As regards economy throughout the entire range of load, much discussion has resulted in comparing the steam turbine with the reciprocating engine operating under the same conditions. As regards reliability of operation it is not too much to expect that when the details of construction of the turbine have been given as much consideration and experiment as the mechanical construction of reciprocating engines the new steam power device will give as good results as the older machine.

As has many times been the case in other lines of development, each will probably find its particular advantageous field of application, and it would be folly to say that either, under all conditions, should be installed in preference to the other.

ELECTRIC LINE TO CHICAGO FROM NEW YORK.

Announcement is made of a project of prominent foreign bankers, associated with Joseph Ramsey, Jr., former president of the Wabash Railroad, to build a double track railroad from New York to Chicago by way of Pittsburg, which will cost about $150,000,000. Surveys have already been made, and it is expected that work preliminary to actual grading and construction next spring will begin this afternoon. The road will require three years to construct, and will be operated with electric locomotives from the beginning. It will be known as the New York, Pittsburg and Chicago Air Line, and will be sixty-seven miles shorter to New York than the Pennsylvania and 108 miles shorter than the shortest line between New York and Chicago.

The new Keystone Air Line will traverse the important bituminous coal fields of Pennsylvania, now controlled by the Pennsylvania Railroad, and will also pierce the anthracite region throughout its length. It will not only be the shortest line through Pennsylvania, but it will cross the summit of the Alleghany mountains 400 feet lower than the Pennsylvania, and will have very easy curves and remarkably low grades for a mountain line.

Mr. Ramsey says the cost of the line between Pittsburg and New York will be between $75,000,000 and $100,000,000, all of which has been pledged, the bulk of it by foreign capitalists.

LARGE ELECTRIC AND STEAM LOCOMOTIVES.*

FREIGHT HELPER ELECTRIC LOCOMOTIVES.

In discussing matters of this kind it is important to know the practical results from actual operation and maintenance, and a report of the comparative performance of electric and steam locomotives in actual service during the past year may be of interest.

Due to certain conditions the Baltimore & Ohio Railroad now has in its service six electric locomotives.

Numbers 1, 2 and 3, each having a total weight of 196,000 pounds carried on four pairs of driving wheels, and number 4, a small switching locomotive, have all been in service for the past ten years.

Numbers 5-6 and 7-8, put into service about September, 1903, are specially designed freight train helping locomotives, each having a total weight in working order of 160 tons (80 tons per section), distributed over 16 driving wheels (8 per section), with a total wheel base of 44 feet 2¾ inches (14 feet 6¾ inches per section), and two 14 feet 6¾ inches rigid wheel bases.

The driving wheels are 42 inches in diameter, each pair being geared to a 200 horsepower, 625 volt, motor, with a ratio of gearing 81 to 19, providing for a total tractive effort at full working load on 8 motors of 70,000 pounds, and at starting of 80,000 pounds, assuming 25 per cent tractive coefficient, giving a nominal rating of 1,600 horsepower.

These locomotives are equipped with electric air compressors for the operation of the brake, signal, third rail safety cut-out switches, track sander, bell and whistle, and also with the usual steam locomotve equipment.

The source of power is a central steam plant generating direct current at 560 volts, from which it is transmitted through feed cables direct to the booster stations, where the voltage is increased to 625, and the current then conveyed to a storage battery which is used as a reserve and for peak loads, as well as to a surface third rail system of contact line, equipped with safety cut-out device. The locomotive motors obtain about one-half the required current direct from each the storage and booster stations.

The free running speed of these locomotives is about 20 miles per hour. On level track, with good current, rail and weather conditions, they are capable of starting and accelerating a train weighing 3,000 tons with a current consumption of 2,200 amperes, which consumption, when speed increases to and is maintained at about 10 miles per hour, reduces to about 900 amperes.

On a 1 per cent grade these locomotives, under similar conditions, will start and accelerate a train weighing 1,400 tons with a current consumption of 2,200 amperes, which consumption, when speed increases to and is maintained at about 10 miles per hour, reduces to about 1,600 amperes.

These locomotives handle eastbound through freight steam locomotives and trains at Baltimore, Md., from Camden Yard to Waverly, a distance of a little over 3.4 miles, returning light. This distance includes seven curves, ranging from 5 to 11 degrees; seven tunnels from 400 feet to 7,000 feet in length, and gradients about as follows:

The first 9,000 feet averages	1. per cent
The next 2,000 feet averages	1.4 per cent
The next 2,500 feet averages	1.5 per cent
and the next 4,500 feet averages	.8 per cent

The time consumed when hauling freight trains weighing 1,395 tons in cars of various capacities and lading, 105 tons in steam locomotives and 160 tons in electrical locomotives, or a total moving load of 1,660 tons, average 23 minutes actual running time from start until electric helper locomotive cuts from head end of train to return light.

During the past one year's service the combined mileage of the four sections comprising these two electric locomotives has been 121,015 miles, computed on the basis of straight light and loaded mileage. The proportion of light and loaded mileage was half and half, and bout 200 miles per month per locomotive of one section was in passenger helper service.

Each section contributes its individual mileage for the distance run, whether it is operated singly, or in connection with one, two or three similar sections or other electric locomotives, although the general practice is that two similar sections are operated in tandem. Therefore, the average miles run per locomotive of two sections per month would be 2,521 miles, which is the figure that must be taken in comparison with the operation of the steam locomotive to be described.

Considering $1.25 per net ton as a base cost for fuel delivered at the power plant, the average total operating and maintenance expenses during the year for generating current; the labor and material for locomotive electrical and mechanical repairs; the engineer's wages; wiping, holstering, inspecting, oiling and dispatching; lubricating and miscellaneous supplies, was approximately $69.00 per 100 miles run per locomotive of two sections. Of this amount the average cost of labor and material applied to each locomotive for the running and shop repairs would be $6.40, or 52 per cent for the electrical, and $5.80, or 48 per cent for the mechanical, making a total average cost of $12.20 per 100 miles run for both the electrical and mechanical repairs.

The above figures do not take into consideration interest, depreciation, taxes nor insurance on the investment, nor do they include the expense incident to the maintenance of such equipment as battery, feeders, third rail, bonding wires, insulation, safety cut-out switches, extra motors, etc., which is not required for steam locomotive operation. The wages for the conductor, or second man on the locomotive, has also been omitted.

During their service considerable difficulty has been experienced with the shoes used for collecting the current from the surface third rail; the loosening and wear of pinions used to transmit the power from the motors to the gears on the driving wheel axles; breakage of gears on driving wheel axles; the lubrication, heating and wear at the armature bearings; the flange and tread wear of driving wheel tire; derailments; stalling and breaking in two of freight trains due to slipping of driving wheels, more especially with wet rails, or when tires of drivers connected in series are not of exact diameters, and in miscellaneous renewals and shop repairs.

The driving wheel tires which, when new, were 2⅞ inches thick, are now 1¾ inches thick, showing only 7,500 miles run per 1-16 inch of metal removed at the tread, and will have to be renewed within a few months. (Note.—Since this report was written locomotive sections 5, 6 and 7 have had all driving wheel tires renewed.)

From experience, to the present date it would appear that an electric locomotive and its source of power, to produce the proper efficiency and economy in operation for either passenger, freight or helper service, should fulfill the following essential requirements:

1. A fire and collision resisting locomotive construction within the present clearance and weight limits; simple in design; reasonable in first cost; safe, reliable and economical for operation at varying speeds and power; and accessible for inspection, lubrication, cleaning, repairs and for replacement on track in event of derailment of any or all wheels, by the ordinary steam locomotive and car methods, without the necessity for the use of a power crane.

2. A locomotive that can be interchanged and operated over home and foreign tracks which are suitable for steam locomotive or motor car equipment.

3. A locomotive composed of two or more interchangeable sections, each a duplicate of the other, and equipped so that each section may be operated from either end, and independently or jointly, with any number of coupled sections;

* A paper read before the New York Railroad Club by Mr. J. E. Muhlfeld, General Superintendent of Motive Power, Baltimore and Ohio Railroad.

the operation under any arrangement to be controlled from a single section by one engineer.

4. The elimination of pilot wheels and the concentration of the entire weight on the driving wheels, with a minimum weight per wheel at the rail of 25,000 pounds; and an arrangement of driving wheels providing for a short rigid and a long flexible wheel base, without excessive end play at axle bearings.

5. The elimination of armatures from locomotive driving wheel axles and the transmission of power to driving wheels not less than 60-inch initial diameter without the use of gearing, in a manner that will insure the economical use of current at the motors for starting and running, and eliminate the accumulation of unbalanced pressure at the wheel and rail contacts, as well as the independent revolution of one or more pairs of driving wheels when coupled in series, which occurs as the driving wheels become slightly different in diameter due to ordinary wear or material, when making transition in current at motors, or when operating on slippery track or over rails, frogs and switches of varying wear, surface, alignment and elevation.

6. The least weight between the track and the locomotive frame carrying springs, to minimize the pressures, lateral thrusts and wear at the rail and wheel flanges.

7. A high center of gravity, so that the vibration of the locomotive, due to the variation in surface, alignment, elevation and curvature of track can be absorbed by the weight suspended over the driving springs.

8. A proper proportion between the electrical, mechanical and dead equipment weights of the locomotive.

9. Locomotive motors compact, ventilated, cooled, protected from internal damage and mechanical injury, and of ample range of adjustment and capacity to permit of continuous operation at varying or full speed or power, and to stand an overload of 100 per cent for three minutes and of 50 per cent for one hour, without excessive heating of armature, commutators or fields above the temperature of the surrounding atmosphere. A thin, tough and elastic insulation material, unaffected by humidity or a temperature of 400 deg. F., and having the requisite dielectric strength.

10. A development of the maximum locomotive power for rapid acceleration and regular working, requiring no transition, as from series to multiple, in the transmission of the current to the motors, and providing for a uniform increase or decrease in tractive power to prevent irregular drawbar stresses.

11. Suitable pumps to provide compressed air for the locomotive power brake, track sander, bell and signal operation, together with steam train heating device, and the other usual equipment.

12. Automatic positive devices on the locomotive to insure protection in event of accidental short circuit, or disablement of the engineer.

13. An arrangement on the locomotive which will automatically provide for electrical braking and return to the line for the use of pulling locomotives, a considerable percentage of the energy that is generated by trains descending grades, or stopping, and which energy is ordinarily wasted in destroying material and equipment by brake shoe action on wheels or rails.

14. A high potential current producing, and an aerial conveying system, reasonable in first cost and economical for maintenance; the generation of the electrical energy at a fire-proof central plant for the least cost per kilowatt hour; the transmission of the lowest current over the minimum amount of metal contained in overhead contact lines, protected for weather, voltage and lightening conditions, and insuring continuous operation in event of line or equipment failure or accident; the conservative use of battery as storage for extra power that can be generated at small cost during light load and utilized to good advantage in the event of breakdown or during intermittent and peak loads; the least number of transformer or converter stations; the minimum feeder, conversion and resistance losses in current, and the elimination of electrolytic action.

FREIGHT HELPER STEAM LOCOMOTIVES.

Steam locomotive No. 2400, which is of the Mallet articulated duplex compound type, was designed jointly by the builders and the railroad, and the construction was completed in April, 1904, after which it was exhibited at the Louisiana Purchase Exposition.

After the closing of that exhibition the locomotive was brought to the Connellsville division and put into regular service on January 6th, 1905.

For the purpose of increasing the capacity of an eastbound track, balancing of the power on the division, and to reduce the number of locomotives and crews required to handle heavy freight tonnage over a busy mountainous district, it was necessary to produce a locomotive with maximum adhesion for tractive and braking power, a minimum rail pressure per driving wheel, and a short rigid, combined with a long flexible, driving wheel base, to adapt it to a mountain line having considerable curvature and gradient. To accomplish this it became necessary to Americanize foreign railroad practice by making use of the Mallet articulated feature, which permits of the use of a maximum effective wheel base, with a materially reduced rigid wheel base, and provides for a helper locomotive that can develop an average through freight train speed without excessive wear. The subdividing of the power through the use of four independent cylinders, pistons, main rods, crank pins and frames, in place of two, and the better balancing of the reciprocating parts, result in less strain on all parts, and reduce the liability for breakage and failure.

While the wearing and total parts per locomotive are increased, they are greatly reduced when compared with the development of the same power by tandem locomotives, and the reduction in concentrated stresses and weight insures a more satisfactory and economical maintenance of those details most susceptible to depreciation.

To reduce the water and fuel consumption and relieve the boiler of unnecessary punishment, the duplex Mellin system of compounding was introduced, with an arrangement of independent high and low pressure cylinders, equipped with inside admission piston and double ported flat valves, respectively, providing for a uniform and maximum tractive effort, large receiver capacity and accessibility for inspection and maintenance.

The application of a valve motion to give good steam distribution; maintain permanence of adjustment; overcome the disadvantages of extreme reciprocating, revolving and suspended weight, wear and liability for failure, as in the modern development of the Stephenson eccentric driven link gear; provide opportunity for substantial bracing of the main frames, and to give accessibility to driving axle bearings, and reduction of motion gear parts and bearings with arrangement in the same vertical plane, accessible for inspection, lubrication, cleaning and maintenance, was given careful thought, with successful results, through the application of the Walschaert gear. The use of this motion also provides a location for the brake cylinders, by which means the brake shoes can be applied to the forward moving side of the driving wheels, which insures more uniform braking action and relieves the running and brake gear and frames of excessive reverse stresses and vibration during the use of the brakes.

All direct pressure steam pipes are outside, and are rigidly connected between the boiler and cylinders, and the flexible pipes being only made use of to convey the receiver and exhaust low pressures have provided for a design and construction that will insure against such leakage of any of these joints as would make their use undesirable. The removal of all but the exhaust pipe from the smoke-box eliminates the objectionable steam pipe arrangement between the boiler

and cylinders, which is generally followed out in American locomotive design.

The total weight of 334,500 pounds for the engine in working order is all carried on the driving wheels, which are 57 inches in diameter. Including the tender, which has a capacity of 16 tons of coal and 7,000 gallons of water, the total weight is 479,500 pounds, or about 193,500 pounds less than the combined total weight of two of the consolidation locomotives that are used for through freight service over this same mountain district.

While the draw bar pull behind the tender of two of the consolidation locomotives is about 79,400 pounds, the draw bar pull of No. 2400 is about 74,000 pounds when working compound, and 84,000 pounds when working simple. The weight of train that can be taken up the mountain by two of the consolidation locomotives is about 2,025 tons contained in loaded steel cars of 100,000 pounds capacity. The weight of train that No. 2400 and one of the consolidation locomotives can take up the grade is about 3,210 tons, contained in similar cars. The above figures are based on the locomotives operating at a speed of 10 miles per hour under fair coal and weather conditions, and with No. 2400 working in compound gear.

The total elevation from Connellsville to Rockwood is 931 feet, the ruling grade between Confluence and Fort Hill being one per cent, and the total distance 43.4 miles.

In through freight service, from Connellsville to Rockwood, No. 2400, singly, has moved, in 36 steel cars, 1,668 tons of lading, and 702 tons of cars, or a total of 2,370 tons in the cars. Adding the weight in working order of the locomotive and averaging the weight of the tender loaded with coal and water at 225 tons, it would make the total weight of the train, including locomotive and tender, 2,594 tons, about 64.3 per cent of which was paying load.

The actual running time was four hours, making an average speed of 10½ miles per hour. When handling this tonnage over the hardest pulls and around 8 deg. 30 min. curvature, as high a rate of speed was maintained as with through freight trains of 1,200 tons total, when handled by consolidation locomotives.

Had this same train of cars been hauled by the standard consolidation type locomotive, it would have required the maximum hauling capacity of two locomotives to have handled it at the same rate of speed, and the average weight of the motive power would have been 304 tons, making the total tonnage of the train 2,674 tons, and about 62.4 per cent of which would have been paying load.

When helping trains consisting of consoldation type pulling locomotive having tractive power of 39,700 pounds, with 40 cars consisting of about 2,400 tons, weight of lading and cars, No. 2400 has pushed 36 of the 40 cars in the train on 3 and 4 degrees curvature, and 1 per cent grade, making an average speed of about 4½ miles per hour, and has pushed the entire train and pulling locomotive, weighing about 2,550 tons, when the pulling locomotive was shut off, at a speed of two miles per hour and maintained the working steam pressure and the normal water level for a distance of one-half mile on the same curvature and grade, and which performance could have been continued.

The performance of this locomotive for the one year period, January 6th, 1905, to January 5th, 1906, both inclusive, is as follows:

Total locomotive mileage (computed on basis of six miles per hour when locomotive is in helper service, and straight mileage allowed when locomotive is handling through freight trains)	44,976 miles
Miles run per ton of 2,000 pounds run-of-mine, 20 to 40 per cent, volatile bituminous coal used	9.26
Gallons of water used per 100 miles run	15,207
Pounds of water used per pound of coal consumed, at temperature of feed water	5.870
Miles run per gallon of engine oil	145
Miles run per gallon of valve oil	200
Miles run per pound of crank pin grease	294
Miles run per ton of sand used	485
Cost of labor and material for running repairs per 100 miles run	$3.16
Cost of labor and material for general shop repairs per 100 miles run	$2.41

The average total operating and maintenance expenses during the year for fuel, water, labor and material for the locomotive repairs, engineer's and fireman's wages, wiping, hostlering, washing boiler, inspecting and dispatching, lubrication and miscellaneous supplies, was approximately $26.90 per 100 miles run. To this figure can be added an allowance on account of mileage credited but not actually run, difference in cost of fuel delivered at power plant and on locomotive tender, and for the maintenance of fuel and water supply plants, and there will still be a large margin in favor of the steam as compared with electric locomotive performance, under fairly similar conditions.

The actual miles run during a twenty-four hour period by this locomotive when available for the Transportation Department use varied from a minimum of 88 miles to a maximum of 154 miles, depending upon the train movement.

During this period the locomotive was used for pushing freight trains up mountain grades between Rockwood, Pa., and Sand Patch, Pa., a distance of 16½ miles, and for hauling through freight trains between Connellsville and Rockwood, a distance of 43.4 miles.

During the last six months of its year's service, August 7th, 1905, to January 6th, 1906, both inclusive, the locomotive was out of service 11 days, on which no mileage was made on account of boiler washing, staybolt tests, repairs, etc., due to ordinary wear and tear, or about 6 per cent of its time unavailable for Transportation Department work.

At Rockwood, the station out of which the locomotive operates when it is in helper service, there have been no facilities, except an ash pit to enable the cleaning or drawing of fires, and water service which permits the rinsing out or filling up of the boiler. The locomotive remains in service out of this point for a two or more weeks' period, and is then taken to Connellsville for washout, staybolt test and the necessary inspection and running repair work.

Allowing for fire-box and boiler tube renewals, heavy machinery repairs, etc., we estimate, from the last year's performance, that at the end of ten years the shop charges for working repairs will have averaged not to exceed 9 cents per mile run.

When operating over combination level and mountain divisions, No. 2400 will consume less coal per ton per mile than the various types of simple consolidation locomotives now in the service, and when operated on a comparatively level line it consumed materially less coal per ton mile. On the mountainous part of the division, the fuel consumption per ton mile is more favorable than for the simple consolidation locomotives, but not to such a great extent as when working on the more level portions of the division.

In mountain helper service locomotives are frequently required to remain at work for extraordinary periods between fire cleanings, and during such intervals with the forcing of fires to the maximum, doing short service and pushing trains up the grade, together with drifting down grade, and long time between trips, there is considerable opportunity for variation in the temperature in the fire-box and flues, which would tend to cause leakage and failure. Under such conditions, however, the 2400 has been able to meet the requirements, and at the same time make use of an ordinary grade of run-of-mine 20 to 40 per cent. volatile bituminous coal, and maintain ample boiler pressure at all times to handle the work.

The general condition of the machinery and boiler on January 6th, 1906, after twelve months' service, was as follows:

Treads of tires show even wear amounting to 3-16 inch, or about 1-64 inch per month; tires calipered uniform in diameter.

High and low pressure cylinders were in good condition, being worn smooth and not oblong or bell-mouth.

The high pressure piston and low pressure slide valves were in good condition. Piston valves have had the packing

rings renewed once and the slide valves have received no repairs.

The engine frames, splice bolts, keys, pedestal-caps, braces, etc., have given no trouble, and there have been no renewals nor repairs.

All driving bearings were in good condition, and wihle there have been two warm journals, due to lack of lubrication, since the locomotive has been in service, none of the frictional surfaces were injured.

The driving boxes were in good condition, crown brasses have given no evidence of becoming loose in the boxes, and are of sufficient thickness to continue in service for twelve months before renewals need be considered.

The driving wheels were fitted up when new with 1-16 inch end play between each hub and box, which has been increased to from 3-32 inch to ⅛ inch, the front and rear driving wheels on both high and low pressure engines having the greater amount.

All parts of the Walschaert gear were in good condition, and the total lost motion between the main driving wheel axles and the piston and slide valves, as measured at the valve stems, with the reverse bar in full forward position, averaged 3-64 inch for the low pressure and slightly less for the high pressure engines and for all engines in full back-up gear.

The boiler, which carries a working pressure of 235 pounds indicated, was in good condition, and there has been no evidence of weakness or any trouble due to staying, leaky seams, leaky or broken staybolts or leaky rivets. The staybolts are of the ordinary straight type, 1 inch in diameter, spaced by 3¾ inch, with tell-tale holes drilled at the outer end.

The fire-box was in good condition, and there has been no indication of leakage, except at the furnace door ring, where two defective rivets were replaced by countersunk head patch bolts.

The boiler tubes were good for another month's service, and there was but one flue plugged, which was due to its collapsing about eight feet from the front tube sheet.

This locomotive will remain in service until the latter part of January, 1906, when it will be removed on account of the tire wear having reached the limit allowable of ¼ inch at the tread; it will then have the driving wheel tires reset, boiler tubes removed, boiler cleaned out, boiler tubes repieced and reset, and whatever repairs that may be necessary given to the machinery, and repainted. It is estimated that the cost to make these repairs and put the locomotive in condition for another year's service, or 40,000 miles run, will be about $750.00 for labor and $250.00 for material, or a total of $1,000.00. (Note.—The approximate cost for the above repairs, which have since been completed, amounted to $759.00 for labor and $366.00 for material, or a total of $1,125.00.)

From the performance up to the present date it has been found that the following features embodied in the design of this locomotive have given entirely satisfactory results, with respect to design, maintenance and operation:

The flexible joints to the high and low pressure cylinder, receiver and exhaust pipes; articulated frame; intercepting, reducing and emergency valve and intermediate chamber system of compounding and simpling; combination hand and power reversing gear; Walschaert valve motion; high pressure piston and low pressure double ported slide valves; high and low pressure cylinder packing; method of securing high pressure cylinders to boiler; single disc main throttle valve; driver, crank pin and other bearings; injectors and water works; lubrication of valves, cylinders and bearings; tracking and riding qualities, going forward or backward around maximum curvature, and when pushing, pulling or braking trains or running light.

There has been no trouble on account of priming, and the results accomplished through the distribution of the work over four instead of two main crank pins and auxiliary parts have been markedly satisfactory.

In consideration of the boiler having 72.2 sq. ft. of grate area, 220.0 sq. ft. of fire-box heating surface, 5,380 sq. ft. tube heating surface, and flat and radial sheet staybolts of the ordinary solid type, the performance of the boiler, fire-box, boiler tubes and stays, with 235 pounds indicated working pressure, has demonstrated that it is economical and entirely practicable to operate well-designed and constructed locomotive types of boiler under severe weather, water, fuel and handling conditions, with from 200 to 250 pounds boiler pressure.

While the boiler tubes are 2¼ inches in diameter and 21 feet in length, there has, with ordinary attention, been practically no difficulty on account of leaky or stopped-up boiler tubes, and the steaming has been at all times free, and such as would enable the locomotive to develop the maximum tractive power under the most severe operating conditions.

There was initially some irregular wear of the flange to the left front driving wheel tire of the forward engine, on account of the cross-equalizer of the spring gear not being sufficiently strong to carry the weight, but after a new equalizer was applied this trouble was eliminated. Several of the driving springs also broke, and the grate gear was redesigned to provide larger drop grate openings.

It also required some experimenting to make a suitable flexible connection between the oil delivery pipe and the low pressure cylinder steam chest, which, however, has resulted satisfactorily.

While it has been noted that quite a number of changes in minor details would be desirable, should other locomotives of this type be constructed, still, when taken as a whole, the design, construction and operation in general can be considered as efficient and economical.

From a transportation standpoint, locomotive No. 2400 has been performing the service of two standard consolidation locomotives, when used as a helper, and when handling through freight trains.

This results in a saving of delay which would produce overtime in many cases, from the fact that a heavy train might have to be held for the second consolidation locomotive helper, whereas No. 2400 takes the place of the second helper and moves the train promptly.

In starting trains it has been frequently noticed that during unfavorable freezing weather conditions, with ice on the rails, No. 2400 would push the train and take the slack between the tender and engine of the pulling locomotive before the latter had moved its driving wheels. It has also demonstrated that it has as great a hauling capacity when backing up as when going ahead; and for the reason that it has seemingly not been stalled since in regular service it may not be out of place to mention here that it has been nicknamed "Maud," in comparison with the renowned mule that moves anything it goes up against.

The following are some of the results that can be obtained from this compound cylinder articulated type of freight locomotive, which cannot be duplicated by other single units of steam, electric or internal combustion locomotives now in use on American railroads:

1. A tractive power of about 84,000 pounds for starting heavy trains and for a speed of 5 miles per hour; and of 74,000 pounds at a speed of 10 miles per hour, placed under the control of one engineer and one fireman.

2. A self-contained machine generating the power necessary to develop its hauling capacity. With electric locomotives, where the source of power is separate from the machine which develops the hauling capacity, the first cost of the locomotive alone is, at present, about 50 per cent. greater per pound of tractive power developed under working load than for steam locomotives of the 2400 type. To this must be added the greater cost for repairs and operation per mile run for the electric locomotive, and the installation,

maintenance and operation of a current-producing conveying, storage, converting and distributing system, which would not be required by either a steam or an internal combustion locomotive, and all of which increase the capital and operating expenses very materially.

3. A total locomotive weight utilized for the development of tractive power in connection with a running gear, which makes the locomotive suitable for either hauling, pushing or braking freight trains containing the maximum paying load per foot of track space, over level or mountainous railroads of maximum curvature.

4. A maximum tractive power with a minimum rail pressure per driving wheel, on account of the total weight of 334,500 pounds being distributed over 12 drivers, and a 30 feet 6 inches total, with a 10 feet rigid wheel base, resulting in minimum wear and tear on bridges, rails, ties and roadway. With electric locomotives the excessive weight concentrated on a short rigid driving wheel base and below the springs, together with the extremely low centre of gravity, results in extraordinary rail pressures, thrusts and wear.

5. The elimination of retarded movement and stalling of trains on account of the usual slipping of driving wheels, as in the case of ordinary simple or compound cylinder steam locomotives, or with electric locomotives where the driving wheels are uncoupled and the current is naturally transmitted to the point of least resistance, which is the slipping wheels, resulting in no increase of power at the dead wheels. A higher tractive power is obtained to the weight per axle than with the ordinary steam locomotive, as the slipping due to the accumulation of high unbalanced pressure at the points of wheel and rail contact, does not occur at the same time in both engines. When one engine commences to slip a reduction in mean effective pressure follows, and it regains its grip on the rail without making it necessary to shut off or throttle the steam supply. The other engine, meantime, has been gaining power, thus preventing any appreciable loss of speed and consequent stalling of the train at a critical moment. These conditions are the same whether the slipping occurs with either the high or the low pressure engine, and the most frequent cause for stalling with electric or simple cylinder locomotives is thus overcome.

6. A tonnage and speed per train that will provide for the least number of locomotives and crews under the control of which the movement of the business is placed. This will result in the balancing of the power and movement of the maximum number of loaded and empty cars per hour over a single piece of track, with the proper degree of safety.

7. A minimum capital, repair, fuel, engine and train crew, oil, supply and dispatchment, cost per locomotive, train, car or ton mile.

8. A maximum retarding effect for the safe handling of heavy trains down steep grades at the highest speed permissible for a proper degree of safety.

9. A uniform turning moment to overcome journal friction of axles; rolling and flange friction of wheels; wave resistance of rail; atmospheric friction at ends and sides of rolling stock and inertia of train at time of starting, which will insure the minimum draft gear, machinery and boiler stresses, and reduce the tire and rail wear.

10. A subdivision of power and balancing, resulting in the minimum strains on the locomotive and track, and a reduced liability for wear, breakage or accident. Broken driving wheel axles on electric locomotives indicate that the more uniform torque does not eliminate the liability for such failures under normal conditions.

11. The minimum amount of dead weight and non-paying load, and the smallest number of bearings and parts per unit of power developed.

12. Ability to move itself and train of one-half rating in the event one set of its machinery or engines becomes disabled.

On a railroad the principal work to be accomplished is the movement of trains from one terminal to another on time, and locomotives are now expected to perform equally well work of the most varied and exacting nature. Speed limits and train loads are increasing each day, and will, no doubt, continue to do so, as the maximum expansion of car equipment and the length of trains, under favorable conditions, have not yet been reached.

The first requirement by the transportation of the Mechanical Department is locomotives of such capacity and in such condition as will move the greatest gross tonnage that can be concentrated per foot of track space in one train at the fastest rate of speed that the track and dispatching facilities will permit, with a proper degree of safety.

How well this demand can be met in one steam locomotive of the present gauge and clearance limits by flexibility and simplicity in design, maximum proportion of adhesive to total weight, good material and construction, pure heated feed water, quickened circulation, compounding, superheating, substantial maintenance, intelligent operation, and other essentials, is a question that must be determined in the very near future; and from this determination will proceed the conclusion as to the proportions of each type of locomotive required in the motive power stock for a large modern railroad system.

Railroads are not operated to save fuel, nor to have locomotives that it does not cost much to maintain and operate, and while economy must be considered as secondary to getting trains over the line, at the same time, the tractive power required, and the limits given within which to acquire this, make it necessary that locomotives be now so designed and constructed that more work will be produced per unit of fuel consumed, and the result should be economy. Whether this economy can be derived from the use of turbine, internal combustion, pneumatic or electric locomotives, or by a further practical development of the present type of steam locomotive, will depend entirely on the local conditions and requirements, and remains for the present and future progress to determine.

It is a fact that electricity as a motive power is superseding steam in many cases for the handling of suburban passenger and freight traffic, and that it may displace the latter for through passenger service, but it will be some time before electrical energy will supplant steam power for the handling of heavy tonnage for any considerable distance.

While the construction and operation of electrical locomotives is still in an experimental stage, their performance during the past year, under varying weather, rail and service conditions, when compared with steam locomotives, shows a cost which will make their present use prohibitive, when fuel must be used to generate power, except in cases of absolute necessity.

Given an electric locomotive complete and crewed, ready for operation, it would require:

For terminal handling: A running repair shed with drop pit and auxiliary facilities; tracks and switches; inspection pit and sand, repair material and general stores supply. For maintenance: A general repair shop and equipment, and many expensive extra parts for quick repairs and renewals for locomotive and plant. And for line operation: Standard gauge tracks; sand supply station; power plant building; boilers; draft arrangement; stokers; coal, water and ash intake storage and distributing appliances; coal crushers; superheaters; economizers; feed water heaters and pumps; condenser equipment; heating, fire protection, compressed air and general and detail lighting systems; engines and generators; exciters; switch boards; piping; oiling system; overhead cranes and machine tools; general and auxiliary feeder and distributing systems; transformers; rotary converters; storage battery; overhead or surface contact lines; bonding; insulation; safety cut-out device; lighting protection device, etc.

Given a steam locomotive complete and crewed, ready for operation, it would require:

For terminal handling: A running repair shed with drop pit and auxiliary facilities; tracks and switches; turntable; ash pit; and coal, water, sand, repair material and general stores supply. For maintenance: A general repair shop and equipment, with a few inexpensive parts for locomotive repairs. And for line operation: Standard gauge tracks, and coal, water and sand supply stations.

Therefore, in building a large locomotive for to-day such design and construction must be adhered to as will not only fulfill the present speed and heavy tonnage requirements, but which will remain modern for several years to come, and in the constructive features must be a combination that will insure the most conversion into energy per unit of fuel consumed, and result in the greatest efficiency and economy with respect to cost for installation, maintenance and operation.

The general features for a modern locomotive may be summed as a reasonable first cost; maximum efficiency for the service, within the track, weight and clearance requirements; the greatest proportion of adhesive to total weight; a capacity to handle the heaviest gross tonnage practicable at the highest desired speed; the greatest permissible distance between coal, water or power stations; economy as regards maintenance and fuel and water consumption; a substantial construction of the least number of parts; and a capacity to perform continuous service without liability of failure.

The general requirements for electric locomotives have already been reviewed.

For steam locomotives the merits of a three-cylinder balanced compound type, with one high pressure inclined cylinder between the frames and a low pressure cylinder at each side outside the frames, having the high and low pressure cylinders connected by ordinary pistons, cross-heads and main rods with the main driving axles and wheels, with cranks at 120 deg., and using a combined receiver and intermediate superheater for the passage of the exhaust steam between the high and low pressure cylinders, should be investigated for passenger and fast freight service.

For slow freight service, where a greater tractive power is desired than can be obtained from a properly designed consolidation type locomotive, it would appear that the use of the Mallet articulated design, as already described, would result in the movement of the greatest tonnage per hour over a single piece of level or mountainous track, with a proper degree of safety, efficiency and economy.

At this period, when changes in alignment and gradient, and reconstruction of old as well as the construction of new steam railroad lines, are being considered, there is every opportunity for motive power engineers to demonstrate the advantages of electric over steam traction.

Some of the mountainous steam railroads present many attractions in the way of permanent and concentrated supplies of cheap coal, gas, oil or water for power, and water for condensing and cooling purposes, which, in combination with suitable means for generating, conveying and utilizing electric current for locomotive traction power, might enable a profitable continuance of lines which are now being abandoned, or which, under the present operating conditions, must sooner or later be replaced at a very great cost.

However, before electricity can supersede steam for tonnage service it must be demonstrated practically from actual installation and operation, and not theoretically, that the results which electrical engineers are predicting will be forthcoming, as railroads are not generally making heavy expenditures to increase the business and revenue and reduce operating expenses unless they have rasonable assurance of the net results.

It has been said that for the handling of heavy tonnage electric locomotives have extreme advantages; especially on heavy grades, in regard to speed; this on account of the steam locomotive not having the same endurance due to a limited supply of steam.

Up to the present time, from actual performance, it has not been found that electric locomotives having almost equivalent tractive power, when handling heavy tonnage on severe grades and curvature, can operate at greater speed than steam locomotives.

Of six geared and gearless electric locomotives now in service or under construction, all are different in design, system or method of controlling, and there is every indication that none have yet practically demonstrated that they can meet the requirements for efficient and economical operation and maintenance.

Should it be necessary, from an electrical standpoint, to continue the use of gearing between the motors and driving wheels, as well as the large number of small diameter driving wheels, for heavy tonnage electric locomotives, to obtain the requisite tractive power, it would be interesting to know how the predicted largely increased speed, as compared with steam locomotives, is to be obtained with a reasonable efficiency and maintenance cost.

The arrangement of the propelling gear on the electric locomotives recently purchased by the Valtellina line in Italy, is one that appeals to motive power people who have experienced difficulty with other types of electric locomotives now in service.

The working capacity of an electric locomotive having a total weight of 160 tons, with 42-inch diameter driving wheels, at a speed of 10 miles per hour on 1 per cent grade, is about 1,500 tons in the train, excluding the locomotive. The working capacity of a steam locomotive having a weight of 167 tons for the engine and an average weight of 58 tons for the tender, with 57-inch diameter driving wheels, at a speed of 10 miles per hour, on 1 per cent grade, is about 2,200 tons in the train, excluding the weight of the engine and tender.

In no instance when operating a steam locomotive of the above capacity under the most severe conditions, has it been found that the boiler could not furnish all the steam required to develop the maximum tractive power of the engine.

Comparing the horse power developed, it has been found that the first cost, cost for operation and maintenance, number of and weight on driving wheels, and number of large bearings requiring lubrication, has, for the electric locomotive, been in excess of that of the steam locomotive, and there has been no benefit with respect to increased average speed on 1 per cent grade.

A steam locomotive in one section can be designed and placed under the control of one engineer and one fireman, which will economically develop as much tractive power as may be necessary to haul the greatest amount of tonnage that can be concentrated in one train of suitable size for safe and quick handling over a division.

The advantage of the electric locomotive for the handling of heavy tonnage would be in the increasing of the capacity of the line, and it might be that the increased business handled would justify an increased cost for installation and operation of electric locomotives as compared with steam locomotives.

When compared with ordinary modern steam locomotives the advantages that the electric locomotives have are on account of no tender for coal and water, which reduces the average dead weight about 60 tons per train, which is equivalent to one car and about 40 tons paying load per train, providing the same drawbar pull can be obtained per equivalent horse power and factor of adhesion, when compared with steam locomotives. Electric locomotives will give the advantage of a high average speed obtained for the same weight on driving wheels, while the more rapid acceleration and a lower maximum speed results in less total power required to drive the train and a lower braking pressure for stopping.

The life of the steam locomotive could be maintained indefinitely by the same process as will be required to keep electric locomotives in serviceable condition, but it has been found during the past that it is more profitable to dismantle obsolete equipment and replace it by entirely new equipment than to continue the old stock in service. This will no doubt apply to electric locomotives when they may have reached the same average age that now results in the dismantling of steam locomotives.

From present indications, any benefit from the increased life of the electric locomotive, as compared with the steam locomotive, would be overbalanced by the cost due to continual renewals and repairs on account of ordinary wear and tear.

The cost for the first installation of power plants for generating current is too high. Under the average conditions the actual cost for the complete installation will range from $100.00 to $150.00 per horse power developed, which is from seven to ten times as much as the cost per horse power developed in the ordinary types of modern steam locomotives at a speed of 10 miles per hour.

The present types of stationary boilers are too costly, and require too much floor space per horse power developed. The merits of good superheaters, economizers, feed water heaters and draft appliances, should be carefully investigated for the purpose of increasing the efficiency and economy of steam boilers, which should be designated to produce more horse power per cubic foot of space occupied.

The cost for coal, ash and water supply, storage and distributing appliances, as well as the expense for generators, high tension lines, transformers, exciters, converter and feeder switch boards and appliances for the distributing systems, all contribute largely to the high initial cost for power plant installations.

The size of the current generating device should not be enlarged to such an extent as will necessitate expensive foundation and building construction, overhead cranes and runways and concentrate too much power in one unit. A combination of reciprocating, turbine and internal combustion generator sets should be given consideration for the purpose of efficiency, reliability and economy.

There is no doubt but that steam locomotive boilers and engines are decidedly more extravagant in fuel and water consumption than the modern power plants which are equipped with all of the refinements. At the same time there is a certain advantage and economy in the operation of a locomotive which in itself produces the power that moves it as compared with one that is dependent upon an outside source for its propulsion, and which results in transmission and conversion losses of the current before it is applied at the motors.

To electrical engineers the report and the remarks will appear to be most unfavorable for the electric locomotive operation. This, however, should not interfere with the development of an electric locomotive and power system which will give more efficient and economical results than what may have been up to the present time, or can be, obtained from steam locomotives.

What the stockholders and heads of railroads generally desire is to originate and move the greatest amount of business possible with the least cost to capital and operating accounts.

The motive power engineers must co-operate in working up designs of electric locomotives. Should difficulty be experienced on account of armature burning out, the electrical engineer should not insist on the weight on driving wheels being reduced to remedy the trouble; and at the same time the mechanical engineer should not require the use of pilot wheels and add unnecessary and ineffective parts and weight, if locomotives can be made to operate safely and efficiently without them.

The locomotive problem must be attacked from a transportation and motive power, and not from an electrical and mechanical engineer's viewpoint. There are sufficient locomotives of all kinds now under construction and in service on American railroads to give correct data as to what can be accomplished under varying conditions by either the electric or steam method of developing tractive power, and it unwhitewashed reports of their performance can be obtained it will be of invaluable assistance to electrical and mechanical engineers generally in meeting the present and future motive power requirements.

THUNDERSTORMS AND ELECTRIC WIRING.

The following letter has been addressed to the Editor of the "Scientific American":

As a matter of interest and instructive value to your many readers, I am reporting an unusual and significant incident that occurred at the branch office of the "Scientific American" at Washington, D. C., during a thunderstorm on the 11th of July, 1906.

During the progress of the storm, lightning struck the electric wires that supply the office with light and power. The fuses of the various lights and fans were instantly burned out, and simultaneously therewith a torrent of water poured from the floor of the building where the wires entered, evidently flowing from the water pipe supplying the various radiators of the water-heating system, which, as is usual, had not been cut off for the summer months, since it is not generally considered necessary or even desirable to do so.

Careful inspection disclosed the fact that the electric wiring was close enough to the water circulation pipe to permit electricity of high voltage to jump to the fine ground connection which the water pipe afforded, and in doing so it burned a hole fully three-eighths of an inch in the water pipe, with the result above noted. I am inclosing you a section of the pipe showing the holes, of which there are two, a large and a small one, and also a piece of the wire. The torrent of water which immediately followed the discharge shows that the larger hole was the result of the discharge. The smaller one may have been produced by a ground during the removal of the pipe, as the water-heating engineer states that a flash occurred as the pipe was unscrewed preparatory to removing it, he having undertaken the work without opening the electric switch.

The lesson which the incident teaches is, first, the value of adequate lightning arresters; and, second, the importance of keeping all electric wiring away from water and gas pipes. The electric wires were properly insulated, and carried by porcelain sleeves through the wooden joists of the building, but the lightning's voltage was heavy enough and the ground connection so good as to make the jump possible. If the pipe had been a gas instead of a water pipe, needless to say a fire would have occurred, which would have been difficult to control in daytime, and disastrous at night.

EDWARD W. BYRN.

Washington, D. C.

GERMANS WELCOME AMERICAN ENGINEERS.

The members of the American Institute of Mining Engineers, who are enjoying a tour of Germany following their recent convention in London, took a trip down the Rhine Tuesday to view the harbors and shipping facilities near Ruhfort and Duisburg, and the Kreb's new steel plant and Frederich-Alfred Foundry, where the best American inventions are employed. In the evening the company was welcomed to Dusseldorf by Lord Mayor Marx at the Town Hall. All the leading men of the Rhenish Westphalian industries and many prominent citizens were present, and the Americans were welcomed enthusiastically.

DISCIPLINE IN THE SWITCHBOARD ROOM.

Paper read before the Illinois Convention at Peoria.

A high-class service in an operating room is the fruit of good discipline. Obtaining good discipline does not imply that the operators have learned a book of rules and passed a satisfactory examination on the same. It is not sufficient that they know what is right, it is the doing what is right that brings about good results.

The selection of girls for operators is the first important step. Great care should be taken to know positively that they are of good character, as experience has proved to me that girls of good character are more liable to have the company's interest at heart. In protecting themselves from reproach, they are also protecting the company.

One of the first things for a young woman to learn, who wishes to press into the world's labor market, is its supremacy over all other matters. Very few young women who apply to me for a position have learned this first and most essential lesson. Unless an operator is willing to recognize the imperialism of business in the telephone world, she is never successful; she invariably grows uneven in her work, half hearted, uninterested and is not regular in attendance or punctual. She soon becomes a disturbing element among operators who obeyed the rules contentedly previous to her appearance in their midst.

Attendance in any line of work is important, but especially so in the operating room. It is not an easy matter for another to pick up the thread in the loom of business that someone has dropped, and go on weaving the same pattern without a broken thread or perhaps a tangle of threads. Each operator is assigned to a certain position for a stated number of hours of the day. In the course of time she becomes familiar with the wants and peculiarities of many of her subscribers. It has been advocated by other companies that it is not best for an operator to become attached to or interested in any position, but I have experimented both ways and find that to make an operator become interested in her work and regular in attendance it is well to assign to her a permanent position and let her become thoroughly familiar with the wants of the subscribers on that position. The importance of attendance can readily be seen when each operator has 150 subscribers that she understands better than anyone else. As every wheel in a watch has its own little work to do, no matter how unimportant, the watch will not keep good time if any wheel fails to do its part. Complaints of service usually occur on a position where a regular operator is absent. An operator must, during certain designated hours, become to an appreciable extent a cog in a great machine, an obscure yet not unimportant factor.

After attendance, I consider punctuality next in importance. An operator should be thoroughly impressed with the importance of this rule from the moment she enters the operating room as a student. If the morning finds her longing for sleep right up to the edge of her working hours, she must not allow herself one moment beyond her usual hour for rising. From a strict observance of this rule operators are soon impressed with the fact that until they arrive there is a halt, as they must report for duty in the dressing room at five minutes of the hour. The chief operator gives three signals from her desk, beginning at five minutes of the hour, to operators in the dressing room. The first signal at five minutes of, is a warning bell; the second signal, at three minutes of, means to form in line in order of position at switchboard, and the third signal, at two minutes of, means to pass into the operating room and stand at right of operator to be relieved. The chief operator then gives three more signals, the first for operators who are to be relieved to pull receiver plugs, step back and form in line to pass out; the second signal is to pass out, and the third signal for operators on duty to draw in chairs and be seated. If any operator is missing at the second signal in the dressing room, the line is held. If she comes running in at the last minute, all out of breath and drops into place in line she feels, although not late, that her day is started wrong. If she fails to arrive in time to form in line with the others, she must pass in alone. Nine cases out of ten, an operator dreads this ordeal more than any lecture that could be given her, as the very silence in the room is a reproach to her. Operators rarely pass in late without walking up voluntarily to the chief operator with an explanation. It is not that an explanation sets them right on their deportment card, but it sets them right with themselves. I believe they would rather I gave them a good lecture than for me not to say anything. The reproach that silence gives is often more effective than words. It brings to mind the story of the little boy who decided to leave home secretly one bright morning, to join a "Buffalo Bill" circus. All day he dodged and hid from every familiar face, dreading the possibility of being taken home by a father or a big brother. When the evening shadows were dropping silently over all, and the stars coming out, he thought of the little home on the hillside and wondered what they were all doing there. It does not take a young boy long to get very homesick and combined with hunger, there is only one desire left. So home he went. He crawled up to the window and looked in. There sat father, mother and sister reading. Had they not missed him? Did they not care? Even the old cat, stretched out before the grate, looked the symbol of contentment. The boy opened the door softly, stepped inside, and waited to be greeted. No one looked up although he knew that they heard him enter. Silence was beginning to be unbearable. If they would only speak to him! At last he made up his mind to speak to them, so he edged up to his little chair and sat down saying, in a very much surprised manner, "I see you've got the same old cat."

It is a strange thing that young women, who give so much thought to their personal appearance, should give so little thought to the training of their voices for ordinary conversation. It occurs to me that is the most noticeable thing about a young woman. No matter how pleasing her appearance, or otherwise, her voice appeals to me before anything else. One always experiences a feeling of disappointment when a pretty young woman speaks in a harsh, loud and discordant voice. The last impression is impressed on the memory and her appearance fades from our thoughts. The training of the voice to become soft, low, melodious and to carry well is the most difficult lesson an operator has to learn. If her voice is naturally low and musical she has only half of her lesson to learn. To be able to throw her voice into the transmitter, without any seeming effort and without any loss of sweetness or expression, is an art in itself, when fully acquired. Operators are trained daily on certain phrases and are allowed to use no others in their dealings with the subscribers. It is desirable that the subscriber shall become accustomed to uniform methods of dealing with the operator, as it tends to prevent unnecessary conversation, thus increasing the speed and uniformity of the operator.

We keep a daily deportment card and regulate the operators' hours and salaries according to records taken from the same for the monthly report. When the monthly report is made up, the operators who have been able to keep their names free from any marks on the daily card are subject to a raise in salary, or day hours at the first vacancy. In this way we weed out the careless and incompetent operators in our service. If an operator has reached the best salaried position, it is because the deportment card shows that she is entitled to the same. If after reaching this point an operator should drop in speed, voice or deportment (which is very seldom) she must step back and let someone pass above

her. After an operator has been in the service for a few weeks, she realizes these important facts, that if she wishes to make a good salary, she must be regular in attendance, punctual in reporting for duty, cultivate a sweet, soft voice, and carry out all of the rules according to the instructions she has been given. An operator is not allowed to remain in ignorance of the rules. Failing to carry out the rules, when due to thoughtlessness, is excusable to a certain extent. Should an operator show a disposition to disregard the rules, we do not allow her to take up our time very long.

Correct cord handling is a difficult lesson to learn. The operators are taught that there is only one way to handle cords and that is by taking the plug between thumb and first two fingers, and inserting and disconnecting with the hand in this position, never allowing any pressure of the hand on the cord near the plug. She is not permitted to drop a cord to the table. I rarely see a case of incorrect cord handling any more.

The information operator's duties consist in looking up numbers, names and addresses that the local operator has no time for. Information must be able to answer almost any question that should be asked her: "What show is in town to-night?" "Information, this is No. 1735, Jones, the undertaker, if any business should come for me I am spending the evening at 165 Third street. Will you see that I am called there?" "Information, could you find out who is talking to her?" These are a few of the many questions she is asked every day outside of her regular duties. The information operator is supplied with a loose-leafed double indexed directory, a card record, a city directory and a railroad time table.

The rural operator's duties are particularly adapted to an operator who is tactful, courteous and thoughtful. She must know the weather predictions and be able to tell whether Smith's people have called in to-day. She must remember if the Smiths are at Jones', providing she is unable to raise anyone at Smith's telephone. There is a sort of free-masonry friendship existing between the rural subscribers, and "central" is considered as one of them. The rural operator receives many useful presents such as sausage, bacon, strawberries, apples, cherries, etc. The rural subscribers dread the thought of losing their "farmer" girl as badly as they dislike to part from a good friend.

This is a season of baseball and we can furnish you the score of any baseball game in the "Three Eye" league and all local games. Each operator keeps a score card and records the innings as they come in. Every operator has a list of subscribers to furnish the score to, as nearly every drug store, saloon and cigar store keeps a score card in its window and gets each inning directly from the Inter-State operators.

Operators are frequently given speed tests to ascertain which is the swiftest. These tests are more often taken on the evening service where the positions are not all filled, and especially when some operator is absent or taken ill and her place is left vacant. The operator who answers the most calls is excused an hour earlier than usual. It keeps them all on the alert and thus the absent operator is not missed.

Courtesy to their employers, to each other and to the patrons of the company, is a point strongly emphasized. An operator who lacks courtesy among those with whom she is daily associated should not be trusted to handle the business of the company.

We do not always find girls of sweet dispositions to work for us, but we do find many who, after they have been with us a while, try to cover their bad points, if they do not efface them altogether. Margaret Sangster says: "Many young women belittle their employment by going to it in the spirit of martyrs, who pity themselves or by bringing to it merely a mercenary motive. Self pity is the badge of weakness and work done for money alone is never noble work. One must dignify the work for its own sake. One must care for the enterprise."

Whenever I find a paragraph like this, I save it for the Sunday service and after they have read it I sometimes ask them to give me in writing their opinions on the subject. I also drill them on the rules this way and they enjoy it very much. They get a wider view of the word discipline and understand the strict observance of the rules is not enforced simply to be obeyed. The feeling of good will and contentment prevails through the office.

The management has the hearty co-operation of every operator in its employ, as its policy has always been to make the conditions such that perfect harmony should prevail. Operators are given thoroughly to understand that they are under the supervision of the chief operator and assistants in the dressing room as well as in the operating room. While we expect them to attend strictly to business in the operating room, they are not permitted to talk shop or speak in a discontented manner among their co-workers. They may talk about their dresses, their engagements and their sweethearts as much as they desire. A hearty laugh and a smiling face in the dressing room are sure tokens of good work in the operating room. We all regard a troublesome operator as a piece of drift-wood, that floats into our midst, scurrys around, misplaces things, then drifts out again—and is forgotten.

Many pleasant little outings are given by the company, such as an annual picnic, a hay rack ride, a theater party and a sleigh ride. They are the connecting links of the seasons, and if you want to see a bright, happy set of young women come to Springfield, but I'll not promise you any wives. They are all under a five-year contract not to get married.

ELECTRIFICATION OF A STEAM RAILROAD.

The first extensive change of the motive power on a surface railroad from steam locomotives to electricity is being made by the Long Island Railroad Company, which is now running a considerable number of electric trains, and is increasing the number as rapidly as possible. It is expected that within a very short time all lines where the traffic is of sufficient density will be electrified, and steam locomotives will be used only where an infrequent train service is required.

This railroad occupies a unique position as compared with other steam railroads, in that the traffic is so predominantly passenger, the passenger train mileage being about eight times the freight train mileage, where ordinarily the two are equal. This, coupled with the fact that the density of passenger traffic on this road is enormous, being nearly 47,000 passengers carried per mile of track as compared with about 6,000 for the whole of New York State, including the Long Island Railroad, and about 2,500 for the whole country. Also, the average haul per passenger (about 14½ miles) is less than half the average for the whole country and 50 per cent less than the average for New York State. These facts show conditions which are particularly well adapted for the advantages of electric traction. However, taken together, the conditions presented here are not incomparable with the strictly suburban sections of many other railroads, and what has been done by the Long Island is interesting as illustrating one method of solving a problem which several companies will soon have to face.

In the May issue of this journal appeared a very complete description of the large power house which furnishes the current for operating the trains, and elsewhere in this issue is given a brief general description of the transmission line and sub-stations. Our next issue will contain an illustrated article on the all-steel passenger cars being operated over the electrified portions of the road.—"American Engineer."

INDUSTRIAL.

THE STRANGEN-WICK SINGLE PHASE ELECTRIC ROAD.

The Strangen-Wick Railway Company, which operates a suburban line near the city of Stockholm, the capital of Sweden, has contracted with the Westinghouse Electric & Mfg. Company, of Pittsburg, for the electrical equipment of the cars to operate the road, using the single-phase alternating current system. This recognition of the superiority of American electric railway apparatus is the result of a test instituted by the Swedish Government about a year ago. In this test manufacturers of electric railway systems from America and Europe entered into competition with the result that the contract was placed with the above company for an alternating-current, single-phase equipment. The order from the Strangen-Wick Company calls for the same type of electric railway motors.

HENRY C. BAKER.

The Crocker-Wheeler Company, manufacturers and electrical engineers of Ampere, New Jersey, have located their San Francisco office at 208 First Street, near Howard. The office is in charge of Mr. Henry C. Baker, who has recently come from the East to take the position as San Francisco manager of his company.

Mr. Baker is an engineer of wide experience, and comes to his new position exceptionally well fitted to take up the work on the Pacific Coast. He graduated from New Hampshire State College in 1899, his course being in the Mechanical and Electrical Engineering Departments. For three and a half years he was conected with the General Electric Company, starting in the testing room, and working in the engineering, construction and repair departments.

After mastering the technical details of manufacture, Mr. Baker became associated with the sales department of the company, being employed in the Pittsburg office, when in June, 1903, he resigned to take a similar position with the Crocker-Wheeler Company.

His connection with the Crocker-Wheeler interests has been carried on in the Pittsburg, Baltimore and Atlanta offices, his last position being in Atlanta, where he was in charge of a territory covering seven southern States.

Mr. Baker took charge of the San Francisco office on July 1st. He possesses a pleasing personality, and this, with his wide experience, makes him a very welcome addition to the electrical trade.

The electrical machinery manufactured by the Crocker-Wheeler Company needs no introduction, as it is already very favorably known throughout the Pacific Coast States, and especially in San Francisco.

An interesting installation of Crocker-Wheeler apparatus is that in the Martin station of the California Gas and Electric Corporation. This plant contains three 4,000 K. V. A. Crocker-Wheeler alternators, which will be driven by the largest gas engines in the world, and which will generate current at 13,200 volts for feeding directly into the transmission line to San Francisco. These generators have been installed for some time, and are ready for operation. It is expected that the gas engine plant will be completed very shortly so that the station may be placed in service.

A fourth 4,000 K. V. A. alternator, generating at 4,000 volts, has also been ordered from the Crocker-Wheeler Company by the California Gas and Electric Corporation, for installation in Oakland. These four alternators are the largest engine driven generators installed on the Pacific Coast.

Although the Crocker-Wheeler Company has been manufacturing alternating current machinery but a short time, it has made a number of other installations on the Pacific Coast, notable among which is an equipment consisting of an alternator, motor-generators and transformers for the Los Angeles Pacific Railroad Company in Los Angeles.

In its direct-current motor sales, the company has always held an enviable record, and particularly since the fire of April 18th, has the excellent reputation of Crocker-Wheeler motors been demonstrated.

Among the printing establishments in San Francisco that have started business since the fire and equipped their entire establishments with Crocker-Wheeler motors may be mentioned the following: Nolan-Davis Company (formerly Barnhart & Swasey); E. C. Hughes Company; Britton & Rey; Geo. Spaulding; Stanley-Taylor Company; James Barry Printing Company; Freygang-Leary Company and L. Sutton. Many smaller printing plants have also been equipped.

An interesting feature of the new installations among the printers is the increased use of monotype machines, practically all of which have been equipped with Crocker-Wheeler motors.

Mr. Baker is fortunate in having to assist him as salesman in San Francisco, Mr. R. E. Martinez. Mr. Martinez has been connected with the Crocker-Wheeler Company in this city for several years, and his large acquaintance with the local users of electrical machinery, as well as his extensive experience makes him a valuable acquisition to the San Francisco office.

The Crocker-Wheeler Company has opened up a branch office in Los Angeles at 447 Pacific Electric Building, with Mr. L. Cummins as representative. The office is under the supervision of Mr. H. C. Baker, whose territory covers the Pacific Coast States of California, Oregon and Washington, as well as Idaho and Nevada.

Arrangements are now being made to open up a branch office in Seattle.

ALLEN'S SOLDERING OUTFIT.

For all electrical work, there is nothing equal to Allen's Soldering Stick, which costs less and does its work more thoroughly than resin, acids, or other similar welders. The Allen Soldering Stick does not corrode the wire nor affect the insulation, its searches out every crevice, fills all the holes, and gives a firm, smooth, flush joint that is as strong as the original material.

Besides the Soldering Stick, the Allen Specialties comprise the Allen Soldering Paste, Allen Soldering Salts, Allen Commutator Lubricant, Allen Liqui(d) Flux, Sun Soldering Stick, Samson Soldering Stick.

The Allen Soldering Paste is an invaluable soldering agent for electric light wiring and for use in annunciators and switchboards.

The Allen Liqui(d) Flux is used for dynamo repairs, and cuts out all the cross-circuiting between the segments, and permits the solder to flow into the tiniest crevice and prevents corroding.

The Allen Commutator Lubricant is especially prepared for use on commutators using either copper or carbon brushes. Whenever cutting, heating, sparking or wearing of the commutator is noticed, a very light pressure of the Allen Commutator Lubricant to the revolving surface of the commutator will restore a normal working condition—the surface will be smooth and glossy, preventing wear on brushes and commutator.

For those who wish a cheaper stick than the "Allen," the "Sun" or the "Samson" will prove reliable and give satisfaction.

The Allen products are sold by all electrical supply houses. They have a Pacific Coast sales manager, whose address is given in their advertisement. They were burned out at the time of the recent fire, but will soon re-establish a branch warehouse in San Francisco. Their specialties have all been officially approved by the Fire Underwriters of the United States. Sample stick free to anyone who uses solder who will send his dealer's name. Booklets and wholesale price-lists to dealers who write. The manufacturer's address is: The L. B. Allen Co., 1322 Columbia avenue, Chicago, Ill.

PORTLAND GENERAL ELECTRIC BONDS.

N. W. Harris & Co. have bought $952,000 first mortgage 5 per cent bonds of the Portland General Electric Company, shortly to be issued by the company for the purchase of the Citizens' Light & Traction Company, Salem, Ore., and another similar property for which negotiations are now under way. The bonds are a part of a $10,000,000 issue, of which $4,952,000 will be outstanding after this issue. The remainder is reserved for future purchases, improvements and extensions under the usual limitations. For the year ending March 31, 1906, the following income account is published:

Gross	$921,940.87
Expenses and taxes	441,434.95
Net	$480,505.92
Interest	200,000.00
Surplus	$280,505.92

The James Leffel & Co., Springfield, Ohio, have issued a very handsome and complete new 52-page catalogue, illustrating and describing their line of steam engines and boilers. The details of construction are plainly shown and fully explained, and the catalogue is one that should be in the hands of any prospective purchaser of work in the steam power line. A copy will be furnished free to prospective buyers, stating their wants, and addressing the company as above. In writing for this catalogue please request catalogue "O."

News Notes.

FINANCIAL.

Fullerton, Cal.—An ordinance has been passed determining the necessity of a public water works, with fixtures, land machinery and apparatus for same and for holding a special municipal election to vote on bonds for the improvement. Amount of bonds to be $35,000.

San Francisco, Cal.—The Underwriters Adjusting Bureau has completed the adjustment of the loss sustained in the fire by the United Railroads. The adjustment places the insurable loss sustained by the street railroad corporation at $437,067.64, of which the corporation itself contributes, under its co-insurance contract, $33,530.57, while the balance of $403,517.07 is distributed among eighty-eight insurance companies.

San Francisco, Cal.—An assessment of $3 a share on its 280,000 shares has been levied by the Spring Valley Water Company in order to repair the damage suffered by the system and to restore it to perfect condition, as it had been before April 18th.

San Francisco, Cal.—Since April 18th estimates have been approved by the officials of the Pacific States Telephone & Telegraph Company, amounting to $1,311,000 for temporary work in San Francisco and in other parts of the territory. Further estimates amounting to $408,000, including $263,000 for office equipment in the main office on Bush street are being prepared. The stock of the company, which was quoted at 108 before the fire, and which dropped to 83 soon afterward, is now quoted at 91.

San Diego, Cal.—A trust deed, which has been filed by E. S. Babcock, president of the Los Angeles and San Diego Beach Railway, formerly known as the La Jolla road, conveyed the property to the Los Angeles Trust Company to secure the payment of $706,000 worth of forty-year first mortgage gold bonds. It is stated that the money raised is to be used for the purpose of extending the road in San Diego, Orange and Los Angeles counties, presumably to the City of Los Angeles.

Sacramento, Cal.—A $50,000 pump for the city water works will be purchased next year.

San Francisco.—It has been about decided by the city authorities to build a viaduct across Mission street, between Bosworth and Marshall streets, in order that the United Railroads and the Ocean Shore, which will pass along at that point, will not interfere with each other. Mr. Mullaly has offered on the part of the United Railroads to give the city $50,000, which is estimated as about one-third of the cost of the construction. It is understood that Downey Harvey, representing the Ocean Shore, has made a similar offer, and that the plan will go through.

San Francisco.—Prospective improvements to be made by the United Railroads of San Francisco as soon as the present emergency is disposed of will reach $10,000,000, and this amount has been set apart for that purpose. The improvements include the expenditure of $1,000,000 on the roadbed.

San Francisco.—Published reports show that the receipts of the Spring Valley Water Company for July were $65,000, as compared with an average for 1905 of between $190,000 and $195,000. This is a reduction in cash receipts of nearly two-thirds. The annual reduction on the present basis of receipts would be approximately $1,500,000. It is admitted that an assessment will be necessary to cover recent losses. It is given out that the payment of the $14,000,000 worth of Spring Valley 4 and 6 per cent. bonds, which mature on September 1st, will be consummated without trouble.

San Francisco.—Fred, Ernest and Laura Berio, children of Francis Berio, who died as the result of a street-car accident on August 6th, 1905, have brought suit against the United Railroads for $10,944.50 damages. Francis Berio while attempting to alight from a car at Powell and Union streets was thrown by its sudden starting. He died three days later. It is claimed that the gripman was careless.

San Francisco.—Contracts have already been made by the Pacific States Telephone Company calling for the expenditure of a large part of the $5,000,000 set apart by the company for improvements during the next two years. The new directory just issued by the company contains the names of 15,000 subscribers, or nearly one-third as many as contained in the last directory issued before the fire.

San Francisco.—The actual earnings of the United Railways of San Francisco for the seven months ending July 3, 1906, were $3,409,212, as compared with $3,920,110 in the corresponding period of last year. This shows a decrease of a little over $500,000, which was much less than was generally expected.

INCORPORATIONS.

San Francisco, Cal.—The National Oil Company has been incorporated with a capital stock of $2,000,000, by J. T. Donahue, J. Martin, C. H. Buck, H. Ohlandt, E. Schwab.

San Francisco, Cal—Certified copies of articles of incorporation of the following companies have been filed: Associated Oil Company, Recruit Oil Company, Inca Oil Company, Signal Oil Company, Bakersfield Oil Company, Coalinga Oil Transportation Company, National Oil and Transportation Company, Pacific Oil and Transportation Company, Yakima Oil Company, Grand Central Oil and Development Company, and Mutual Pipe Line Company.

Los Angeles, Cal.—The Eagle Rock Water Company has been incorporated with a capital stock of $200,000 by P. F. Schumacher, A. C. Helbrig, G. Edwards, W. R. Myers, W. B. Judson, G. F. Morcom, E. C. Kulli, E. P. Hillker and J. A. Winans.

Butte County.—The Chico and Northern Railroad Company has been incorporated with a capital stock of $1,000,000 by I. W. Hellman, J. S. Israel, H. M. Holbrook, J. C. Kirkpatrick and C. A. Harp.

TRANSMISSION.

San Bernardino, Cal.—J. C. Taylor of Los Angeles has filed on 3,700 inches of water in the Forsee and old channels of Mill Creek for the Union Power Company, his intention being to generate electrical energy for San Bernardino, Los Angeles, Orange and Santa Barbara counties. It is said that Taylor is acting for promoters who contemplate a consolidation of all the power interests in Southern California.

Redding, Cal.—The Northern California Power Company is furnishing power to the Brunswick Mine & Mill in French Gulch.

Carson, Cal.—Plans have been completed for a large electric generating station to furnish power for the Mammoth Mine, twenty-five miles south of Carson.

Marysville, Cal.—Daniel Ransome Clarke was killed in a pit at Colgate while at work installing new machinery at the Bay Counties Power Co.'s plant. Clarke and two others were in the pit when one of the pipes holding the water gates shut gave way, the gate flying open and allowing the water to rush in. Stones were washed into the pit, one striking Clarke upon the head and killing him. He was partially buried and the body had to be dug out when the flow of water was stopped. Clarke was 51 years of age, and leaves a widow and one child.

Salt Lake, Utah.—The Institute Electric Company has been granted a new franchise by the Board of County Commissioners, and will construct a plant for the generation of electric energy and light throughout the county.

Missoula, Mont.—The visit of Senator W. A. Clark has resulted in the issuance of orders for the completion of the power dam near Bonner at once, and for the installation of a sub-power station in the building situated back of the First National Bank block, recently purchased by the light and power company, and now used as a heating plant. Work upon both projects will begin within a few days, the light plant to be completed within sixty days and the dam to go up as fast as the material can be supplied.

Oroville, Cal.—Guy C. Earl of Oakland, who is interested in the Western Power Company, and M. A. Veille, a New York engineer, are here and it is stated that work on a 40,000 horse-power plant in Dark Canyon will be begun very soon.

Honolulu, T. H.—The first plant in the Hawaiian Islands for the long-distance transmission of high voltage electricity has been formally inaugurated on the island of Kaui. The plant in Wainiha Valley consists of three and a half miles of tunnel and two miles of ditch, conducting 60,000,000 gallons of water a day from the Wainiha stream at an elevation of 655 feet above sea level. Here it is dropped through thirty-inch steel pipes a distance of 500 feet to water wheels operating three-phase generators of the alternating current type and developing 3000 horse-power. The electricity is generated at 2200 volts and is transformed to 33,000 volts, and then transmitted over three aluminum wires thirty-five miles over the mountains to the McBryde plantation, where it is stepped down to 2200 volts and utilized in pumping water for irrigation.

TRANSPORTATION.

San Francisco, Cal.—The McAllister street cars began to operate last week under their new electric traction equipment.

San Francisco, Cal.—The pickets of the striking electrical workers believe that they will be able to intercept the non-union men arriving to fill the places of the striking men and persuade them to desert the United Railroads. It is stated that fully one-half of the strike breakers employed by agents of the United Railroads have been persuaded to desert the company.

San Bernardino, Cal.—It is stated that the route of the Traction Company from Eighth street to the city limits has been decided upon and the City Council will be asked for a franchise over the selected streets.

San Francisco, Cal.—The engineering department of the Ocean Shore road has announced that its working force is to be increased soon by several hundred men, with a view of hastening the completion of the road between here and Halfmoon Bay. Track-laying between Spring Valley and Mussel Rock, a distance of six miles, has been finished and the grading of the new line in the vicinity of Halfmoon Bay is being hastened.

Merced, Cal.—Another section of the Yosemite Valley Railroad has been put in operation, consisting of fourteen miles of road from Merced Falls to Pleasant Valley, making thirty-nine miles in all which are now in operation. Track connection has been made at Merced with the Southern Pacific and the Santa Fe railroads.

Petaluma, Cal.—The Pacific Coast Western is the name of the new electric road proposed for this section. It will run from Petaluma to Tomales, thence to Bodega, touching at Bloomfield.